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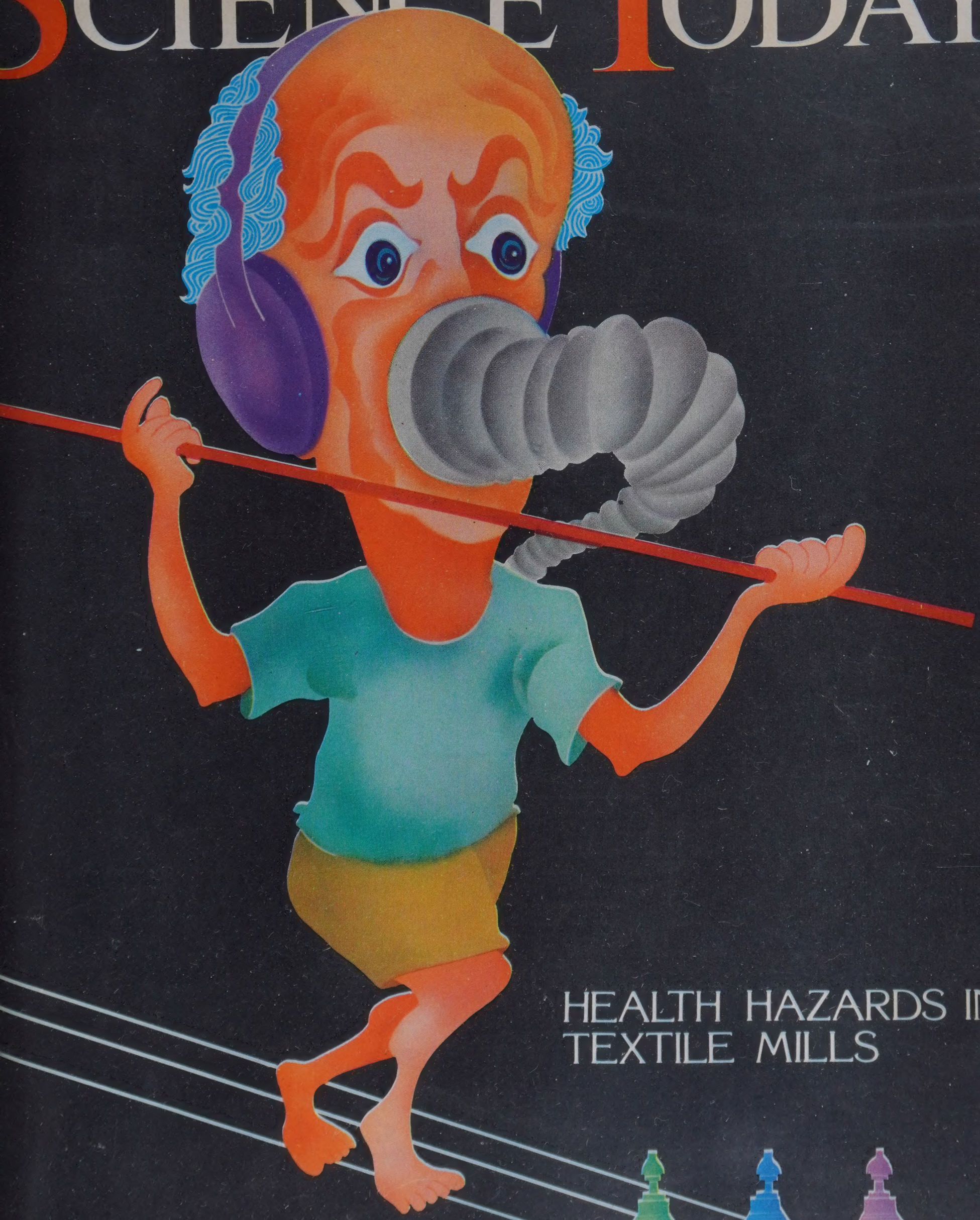

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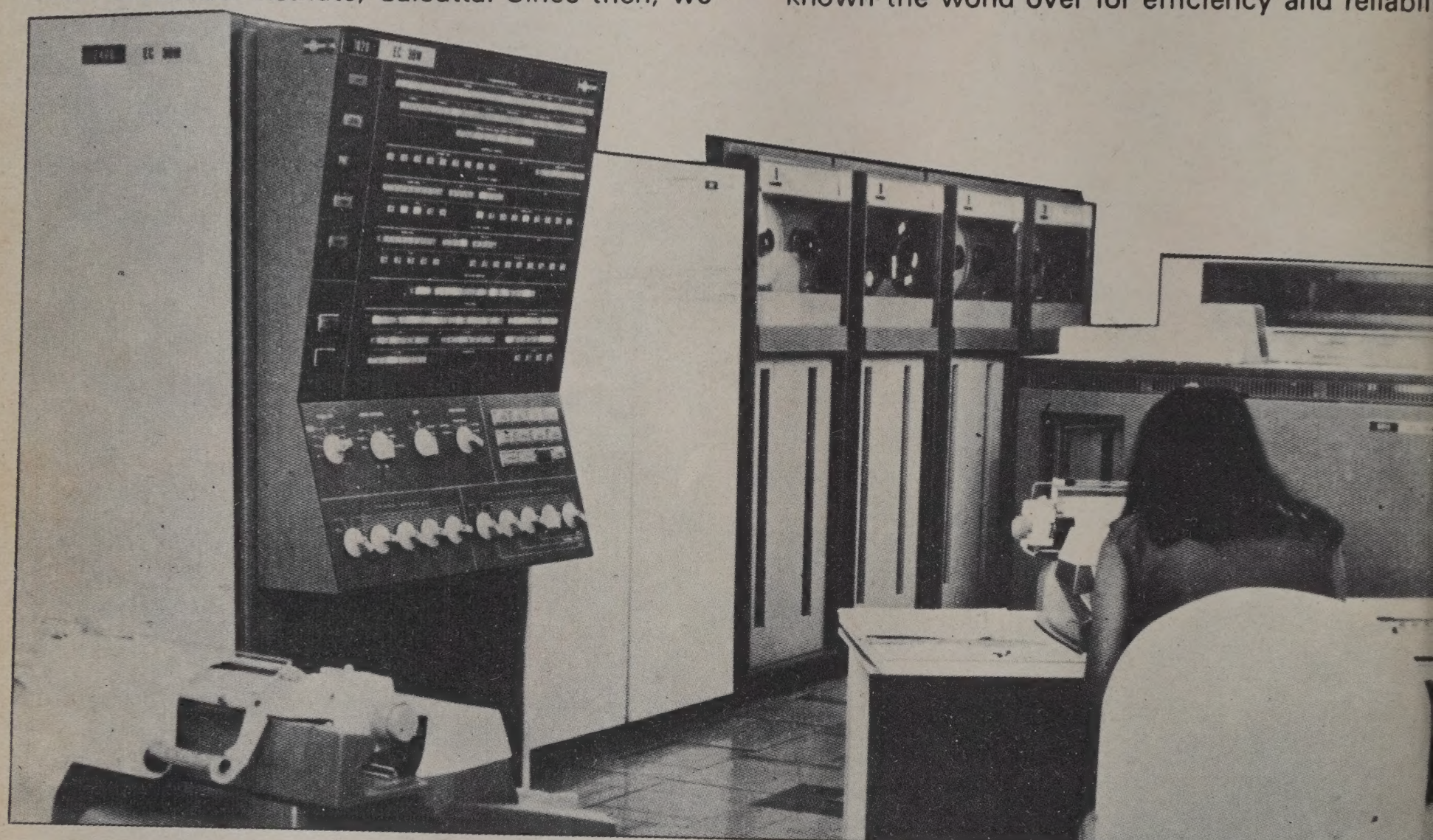

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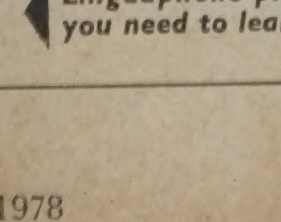

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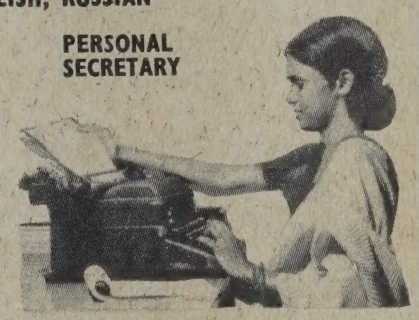

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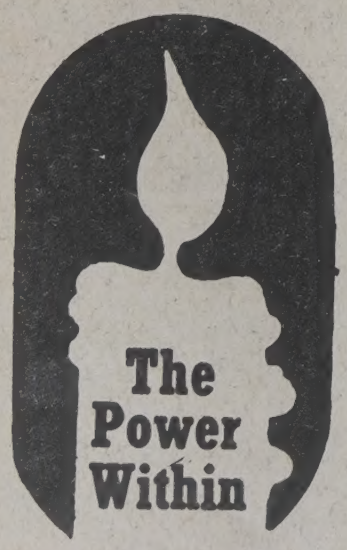

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13 PHOTORESPIRATION IN PLANTS

S. C. Maheswari & Meena Budhiraja

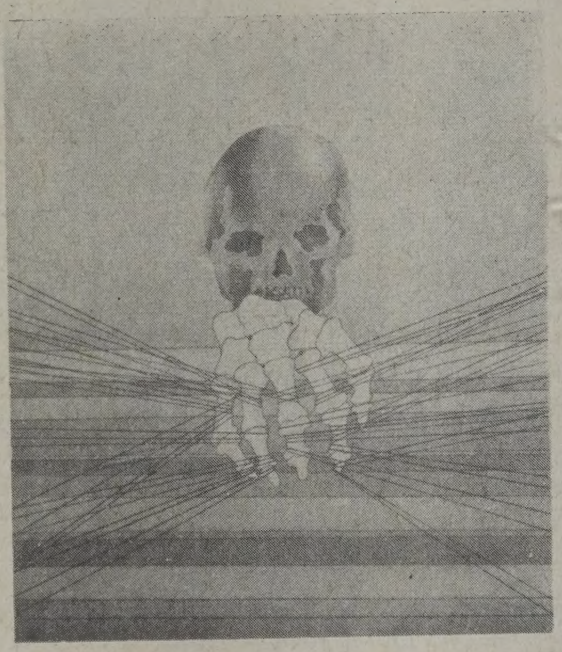
Why should some green plants release carbon dioxide and take up oxygen in the presence of light, when they should be doing just the opposite? The puzzle is several decades old

18 SOME THOUGHTS ON INDIAN SCIENCE...

Atma Ram

Last month SCIENCE TODAY initiated an informed public debate on our science policy and our plan priorities. This month, the Chairman of the NCST gives his views

25-37 HEALTH HAZARDS IN TEXTILE INDUSTRY



There are nearly 1·5 million textile workers in India. One-fifth of these are victims of respiratory disorders caused by inhalation of cotton dust. The victims of toxic chemicals, heat, humidity and noise are yet to be counted. This special study probes the hazards faced by textile mill workers in India

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Harwant Singh

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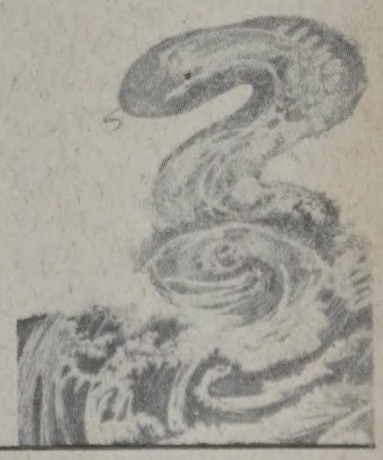
S. R. Amladi

This month: trees of our coastal regions

45 THE COILED SERPENTS FROM THE SEA

A. K. Mukherjee

The destructive power of revolving tropical cyclones is recent memory in India. Despite their several enigmatic features, accurate forecasts depend partly on the modern technological aids and mainly on the meteorologists' ingenuity



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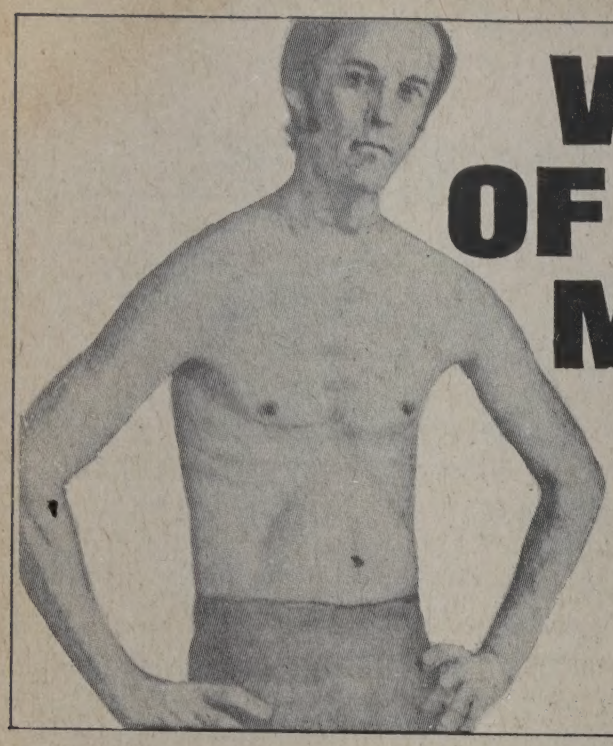
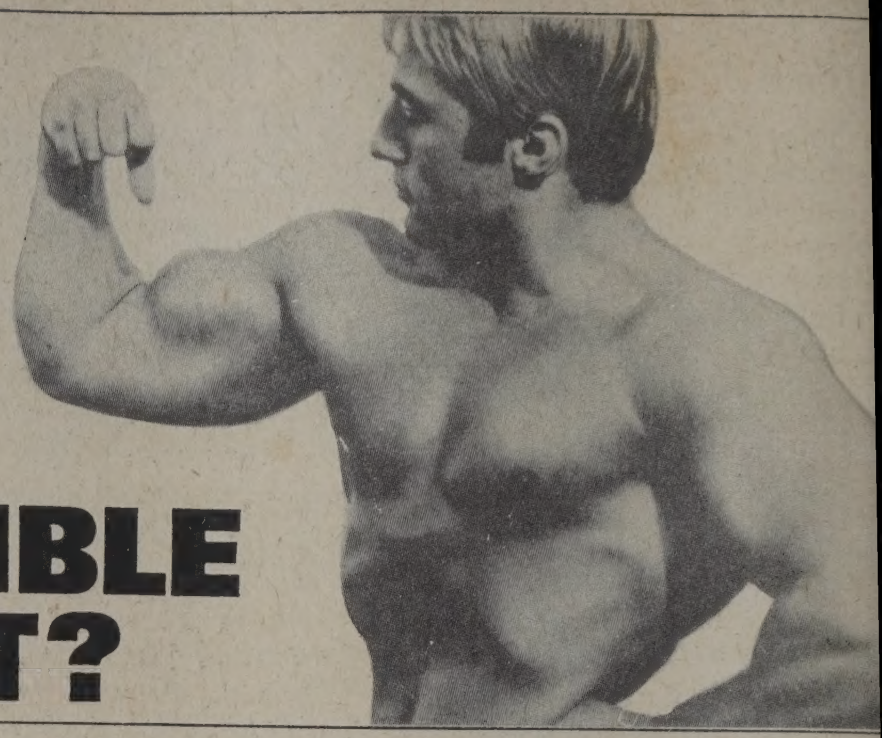


WHICH OF THESE MEN DO YOU RESEMBLE MOST?



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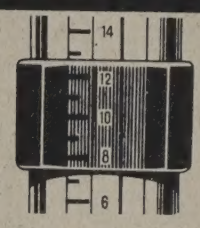

means you can actually watch your muscle-power G-R-O-W-I-N-G day by day!

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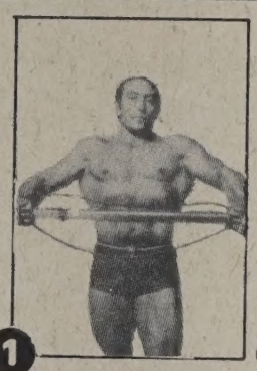
Fitness Expert reveals how these 7 exercises can build you a power-packed body in exactly 49 seconds a day!

This is Len Sell, former Mr. Universe, demonstrating the simple series of 7-second Bullworker exercises. This exercise develops Deep Muscular and powerful chest.



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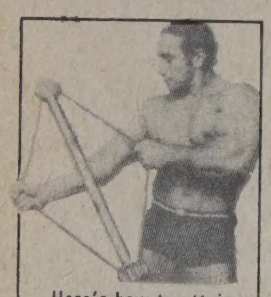
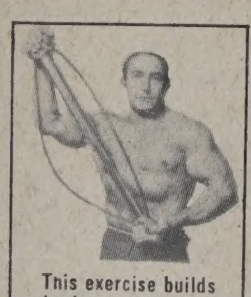
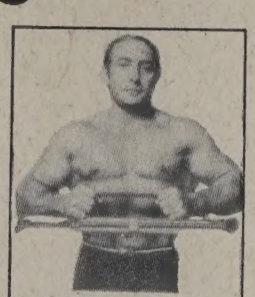
2 This exercise builds steel-like rippling biceps.



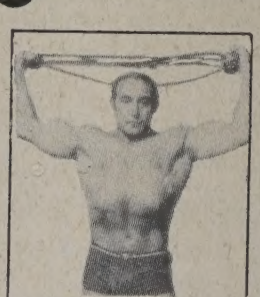
3 Here's how to attain that handsome athletic "V" shape.



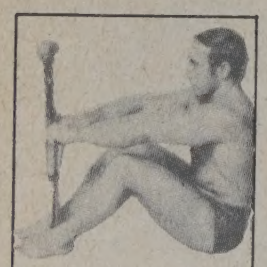
4 This exercise builds back muscles, gives you that "man of action" look.



5 This one charges your forearms with new strength



6 Here's how you can develop muscular shoulders.



7 Moulds Abdominal Muscles into a taut, firm and slim shape.

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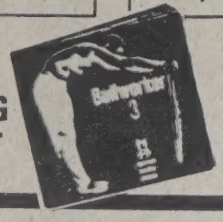

shows you the easy, step-by-step Bullworker method. You begin with the easy, stimulating introductory series of exercises that anyone can do. (Takes just 49 seconds!). Then, as your muscle power increases, you gradually add more exercises, until, after just a few days, you'll find yourself breezing through the complete 5-minute daily programme with ease.

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nemonics

his is to point out a glaring omission in nemonics — Looking into Memory s " (November 1977). Mr. Pradip Paul rs to Western mnemonists but does even mention the Indian system ected over thousands of years. It is an isputed fact that many of our ancient s, notably the *Vedas*, had a long aural ition before they were transcribed. And were handed down with an accuracy ch, to say the least, was remarkable.

he system followed was one whose nents can be found in Hindu, Jain and ddhist texts. The emphasis throughout s on the development of a true scholar to that effect the training was on four n lines : (1) directing the thoughts only vards the desired goal ; (2) ncentration ; (3) imagination ; (4) cialised techniques. These were veloped through innumerable exercises all sorts, specialised diets, yoga and *ntras*.

' Specialised techniques " included tailed classification, association, and er methods. The ' digit-letter ' system ntioned in the article has been in use in lia for at least 2,000 years, though the urce is unknown. The system, I may int out, is very much more suitable to Devnagri alphabet than the Roman, the flexibility and the range in the mer is immense. The vowels can be ed independently or fused (through *ntras*). Again, there are 12 vowels in vnagri as opposed to five in English nd French, German, etc) and ten in ssian. We can note the same feature th regard to the consonants. The current stem is as follows :

न ण क ख
र ट ठ ड ढ
ग ध
च छ ज झ
प फ
ब भ म
व त थ
श ष स
ह ल
द घ

There are no vowels. The letter 'य' is iso absent.)

The Indian system believes that the ourth aspect (specialised techniques) is f no value in scholarship if the first three re not simultaneously developed. The ommercial courses, as is well known, rovide only these ' formulae ' for success.

The degree of development achieved can e phenomenal. Theosophical literature nentions persons with the power to concentrate on and memorise eight things simultaneously (for example, chess problems, puzzles, phrases in foreign anguages). Perhaps even more surprising would be that at least two people today have the title of *shatavdhani* (शतावधानी) — with the ability to concentrate on 100 things simultaneously. One is Mr. Dhiraj Bhai Shah, whose book on memory has been published in Gujarati. The other is the Jain monk Munishri Mahendra Kumar Ji Pratham who has published more than 70 books — two of which are on memory.

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Perhaps in this field we Indians are the pioneers. Our ancestors had perfected the system of depicting numbers by alphabetic letters in Sanskrit. The system in Kerala is known as *Paralperu* and is widely used by astrologers in the computation of planetary movements and other astronomical calculations connected with astrology. The system, if I am informed correctly, does also have the name *Akshara Samkhya*. The former relates to coining a name (word) for a particular numerical figure which probably is a constant. The latter relates to attributing a number (*samkhya*) to a letter (*akshara*).

In the field of the then prevailing sciences, our ancestors had also developed the perfect memory aid system of *slokas*, probably centuries before the Westerner coined the " formulae ".

Today Sanskrit is being revived. If only some gifted person will take it upon himself to write the texts for science subjects (up to secondary school level, at least) in Sanskrit *slokas* — just like *Leelavathi* of Bhaskaracharya — what a relief it would be to our students !

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About memory courses

Answering the question " Will a memory course make me a better scholar ? ", Dr. S. Ramani says that a memory course is just a mnemonic system (" Memory courses : a few questions ", November 1977, p. 44). Just as reading and cricket need skills which can be improved upon, remembering is a skill which can be developed and trained, too. Surely, " memory " is an important function, and training it would help one to be better equipped. Our educational system is ' memory-oriented ' and calls for a lot of ' mugging ' because the system of how to learn, retain and recall is not covered by the teacher. The ' retention ' aspect has been completely missed out ; this is why many students would not be able to recall lessons they studied years ago.

A ' memory course ', in its true sense, is a training imparted to a person to learn by understanding, retain by systematic set pattern techniques and recall confidently through advanced time-effort-saving techniques developed by educational psychologists and study-management experts. All good books on ' memory improvement ' will have only one chapter set aside for ' mnemonic aids' which proves that mnemonic aid is only one of the many techniques available in a full-fledged memory training syllabus and repertoire.

Available memory systems should be used only as a ' crutch ' — if no method other than ' rote ' or ' cramming is available. About mail order business (leaving aside memory courses), ' promises ' are sold, in small or large measures, depending on the talent and flair of the advertising copywriter. In return, it is the buyers' game to utilise the full value of the product they go in for.

The book by I. M. L. Hunter is a further reading text, only after one has been personally trained or follows a ' How-to-do-it ' or ' Do-it-yourself ' course in memory training.

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Dr. Ramani writes : **A memory course need not, of course, be limited to description of mnemonic systems. It can attempt, in addition, to give the reader a framework for understanding a variety of psychological phenomena relevant to the subject. It can attempt to give him practical advice.**

But I have pointed out that one could read popular books on psychology for this purpose, books by well-known authors, published by established houses. The most important fact about such books is that they are available for public review. If a publication such as SCIENCE TODAY asks the publisher, it would get a copy for giving to a professional reviewer. On the other hand, there is no professional review to which memory courses are subjected to. You have no one's word, except that of the vendor, that it is worth anything.

A memory course that I scrutinised recently turned out to be really worthless in every way except that it provided descriptions of a few mnemonic systems.

I do not agree that one has to take any " How-to-do-it " or " Do-it-yourself " course on memory before reading I. M. L. Hunter's well-known paper-back *Memory*. This book is available in most bookshops and the readers can judge it for themselves.

I would borrow a phrase from Mr. Vaz and say, all types of courses are advertised ; it is the buyer's game to make sure that he is not fooled.

What about Luria ?

There was no reference to post-Pavlovian Russian workers in the field of memory, particularly the work of A. R. Luria and his associates (" The biological mechanism of memory ", November 1977 p. 15). The references to brain lesions in Prof. Siddiqi's article appear to deal primarily with non-human situations. Luria's work, for over 40 years, has been devoted to the psychological study of

patients with local brain lesions. He analysed changes taking place in the mnemic processes in patients with localised brain lesions, and used the results to describe the structure of these changes. The analysis is presented in his book *Neuropsychology of Memory* (1973), published by Pedagogika Publishing House, Moscow (Russia). For readers interested in Luria's work, there is a fascinating Penguin paperback : *The Working Brain : an Introduction to Neuropsychology* (1976).

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It seems the Printer's Devil has a short-term memory. Dean Wooldridge's book is not *Machining of the Brain* — God forbid !—(p. 42, " books for further reading "), but *Machinery of the Brain*. Can't we also include *Human Reason Vs. Computer Logic* by Weissman ?

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Scientific articles and editorial ideas !

My article " Biological Mechanism of Memory " (November 1977) has been illustrated by a drawing on p. 26 which I find quite grotesque. At any rate, it has no connection with anything said in the article. Again, the title of the article in the

manuscript was " Biological Mechanisms of Memory." The plural was intentional and meant to emphasise that there may be no single unitary mechanism of memory. Also, the drawings *above* and *below* the caption in Fig. 4 have changed places.

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Sweetener for ice candy ?

G. Veerachandra Rao (Letters, " Sweetener for ice candy ", November 1977) has wrongly assumed that artificial sweetener is permitted in ice candy under the Prevention of Food Adulteration Act, 1954. Under the fresh standard laid down for ice candy under Rule A.07.04 of the Prevention of Food Adulteration Rules, 1955, effective from 2 April, 1977, the use of any artificial sweetener in ice candy is expressly prohibited. The use of any artificial sweetener in ice candy would render ice candy adulterated under the Act and the manufacturer, seller or distributor of such adulterated ice candy would render himself liable for severe punishment. The new standard reads : "A.07.04—' ICE-CANDY OR ICE LOLLIES OR EDIBLE ICES ', by whatever name it is sold, means the frozen ice produce which may contain the permitted flavours and colours, sugar, syrup, fruit, fruit juices, nuts, cocoa, citric acid, stabilisers or emulsifiers not exceeding 0·5 per cent. It shall not contain any artificial sweetener".

Under Rule 44(g) read with Rule 47, only one artificial sweetener, saccharin, is permitted in carbonated waters to the extent of 100 ppm under Rule A.01.01.

In the circumstances, it would be futile and criminal for anybody to take up the manufacture of any artificial sweetener for use in ice candy. Saccharin itself is under a cloud and, in our opinion, it ought not to be allowed even in carbonated waters and its use as an artificial sweetener should be totally prohibited.

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Suicidal plants — not a novelty in Kerala

In the October 1977 issue (Science Shapes Life) there is a reference about a species of trees (*Tachigalia versicolor*) growing in the Panama Isthmus that commits suicide. This is hardly a novel phenomenon. Almost all varieties of " bamboos " common in Kerala display similar characteristics. Some of these bamboos have a lifetime of 20 or more years and grow to a height of 10 or 15 metres. But they flower and release seeds only once in their lifetime. Along with the releasing of ripe seeds, they dry off. There is no regrowth from any part of the mother plant. The progenies are from the seeds only.

There is one more peculiarity about these bamboos : when the flowering season comes, all the living bamboos (from the oldest to the youngest) over a wide region flower and die. Thereafter, the seedlings from the seeds take a few years more to grow to the ordinary size.

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' Beware of the matka !'

The advertisement of Balsara's Puritas Water Filter (August 1977, back cover page) " Beware of the matka ! " contains an erroneous information which can do great damage to our tradition of storing cool water in clay pots. It is quite true that clay surfaces can offer the proper environment for bacteria which cause water-bor diseases, but a specific infection is necessary for ' breeding germs by t millions '. So it is incorrect to say th stored boiled water ' breeds germs ' Matkas are incomparable for provid cool tasty water because gases diss through the pores to improve the ta of water. Glazed vessels are just pas containers which do not have these properties. Water coolers are expens consume power and chill the water is too cold to drink comfortably. Eve we use a Puritas filter, we will still s the water in a matka.

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Modern science and ' consciousness '

The November issue of SCIENCE TODAY contained two articles which attempted to explain the phenomena life (conscious activity) in terms of th scientific materialistic philosophy. The article by Prof. O. Siddiqi, although entitled " The Biological Mechanism Memory ", never did explain the mechanism by which unconscious electrons and molecules suddenly acq the conscious ability of " memory ". S cannot challenge doctrinaire statemen on scientific grounds. Until the mecha of how matter produces life can be explained, or how the unconscious produces the conscious (which is *like* trying to explain how a shadow produ light !), then the *a priori* doctrine of materialism lies beyond the domain of objective science.

The second article by Dr. Vivek Monteiro on " Entropy " claimed that t source of order or information for a livi organism comes from the ingestion of negentropy from food, thus eliminating " intervention of a conscious, intelligen agent " from the picture. However, the overall order or information of a system a whole which cannot be reduced to th sum of its parts or units of information. For instance, nursery rhymes fed into a computer and then combined at rando could never be expected to produce th *Ramayana*. The information content of each rhyme, even if added together wit the information of the others, would no sufficient for producing anything more complicated than a nursery rhyme. In fact, the same negentropy in an apple produces a rat's body when eaten by a rat, and a man's body when eaten by a man, implying that there is an indepen source of information ordering the incor negentropy according to the individual.

These arguments can be presented quantitatively using a general theorem o information developed by Caitin and Kolmogorov : a system of complexity (information content) C cannot be generated from a system of complexity C' if C' < C. A recent monograph by R. L. Thompson entitled *Demonstration Information Theory that Life Cannot Ar from Matter* (Bhaktivedanta Institute Monograph Series No. 2, Bombay) clearly proves the devastating effect tha information theoretic analysis has on

utionary theories involving chance. ond this, in another monograph by the e author *Consciousness and the Laws ature* (B. I. Mono. Sr. No. 3), it is vn that a conscious agent is essential odern physical descriptions to make e of quantum mechanics. This tion has been held by scientists such . von Neuman and E. Shrodinger, and ntly E. Wigner has refuted all osition to this interpretation.

ne existence of a conscious agent in ure may seem strange to modern nce because of the recent predominance naterialistic philosophy, yet the ntific, rational approach was viously used and even developed er the more traditional spiritual spective. Like the electron or atom ch cannot be directly observed, erimental evidence of a conscious nt can be inferred from its interactions n matter (summarised in *What is tter and What is Life*, by T. D. Singh R. L. Thompson, B. I. Mono. Sr. 1). The concomitant existence of terial and non-material principles is also nd in modern science where the " laws nature " although real are not made of terial substances. Thus, it is possible to nstruct a strictly scientific paradigm ving both life (consciousness) and tter as distinct, irreducible principles. s only a matter of scientists directing ir theoretical and experimental research orts to popularise this view which, ving been long neglected, has been errun by pseudoscientific and fanatic -called spiritual and meditation groups.

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Dr. Monteiro writes : I am surprised that ch trivial objections should be raised by ree PhDs from reputable universities. he authors don't seem to have clear eas about the concept of entropy (and e associated concept of negentropy). they did, they would not make atements like " the same negentropy in n apple produces a rat's body when aten by a rat, and a man's body when aten by a man, implying that there is an dependent source of information rdering the incoming negentropy ccording to the individual ". For one, egentropy cannot be ordered and isordered like the papers on a table, or ke molecules in a gas. Negentropy is a *easure* of this order, a subtle sort of easure which can be exchanged etween interacting systems, like its ounterpart entropy.

Why is it so surprising that negentropy produces a rat's body when eaten by a at and a man's body when eaten by a nan ? " Are the three PhDs surprised by he fact that the same negentropy in etroleum produces polyethylene in a olyethylene plant and PVC in a PVC lant ? Do they feel the need for an ' independent source of information " to explain the process of polymerisation in

I had a rare opportunity to save a teenager from a possible calamity by the knowledge that I had gained through SCIENCE TODAY (June 1977). The article " Of Fangs That Kill " by Dr. Bhide and Mr. Bhise, and particularly the photograph of the fang marks in a viper bite, helped me to identify the viper bite in the case of this boy living in my neighbourhood who was bitten by a snake ; the victim was quite careless thinking that it was a non-poisonous one. On my insistence he was rushed to the hospital where it was also diagnosed to be a viper bite.

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the above two cases ? If so, then they should publish their theory immediately since it would be of great scientific and, possibly, commercial importance. If not, then at what stage in the ladder of complexity, which leads from organic chemistry to biochemistry to self-replicating molecules to bacteria and further, is it necessary to invoke this " independent source of information " ? At around which chapter of, say, Watson's book *Molecular Biology of the Gene* is it necessary to introduce a section on Theology ?

Not more than a few hundred years back, an " independent source of information " lurked in every dark corner of human and social experience.

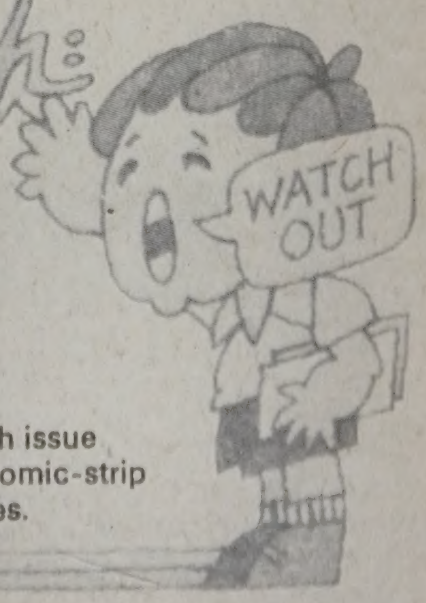
Not only did God create the world, but He also made sure that the Sun went round the Earth, and that the planets wandered erratically in the skies. Then Copernicus, Galileo and Newton brought in the solar system and gravitation, unwittingly banishing the " independent source of information " back to the beginning of the universe, where He has been biding His nonexistent time, ever since.

In subsequent centuries, a thorough search of innumerable other dark corners of the real world as undertaken by physicists, biologists, etc, did not reveal any independent ghosts to be hiding there, though this work did unearth many new dark corners. After this fruitless and frustrating search, some people came to the conclusion that, " Dark corners do not contain ghosts ", but this is often challenged by those like the three Doctors who say that, " You haven't searched all the dark corners ". This group should also include those who say that, " You can't say that the sea is salt until you've tasted all the water."

The computer and nursery rhyme example is not worthy of comment. As for the theorem of Chaitin and Kolmogorov cited by the Doctors, it is (theoretically) closely related to the Second Law of Thermodynamics. As pointed out in my article, there is no contradiction between the latter law and the processes of ordering which take place in nature. So I am at a loss to understand the Doctors' purpose in citing Chaitin and Kolmogorov's theorem. They have not explained the rather technical concept of ' complexity ' of a number, they have not explained its connection to the concept of negentropy (which is the relevant measure of order in processes involving organisation of matter), and lastly, how the theorem has a devastating effect on anything, including the assertions made in my article.

It is difficult for me to criticise the Doctors' statements, because there is so little logic in anything they have said. These statements on examination are quite disconnected. Some, like the first one cited, are meaningless. Some, like the theorem cited, are irrelevant. Many, unfortunately, are misleading. What does it matter if Wigner held the position that the Doctors wish to promote ? Wigner was one of the most rabid supporters of the American war on Vietnam. Does that lend any legitimacy to that war ? Substituting the name and fame of individuals, quoting difficult sounding theorems which are incomprehensible to the reader, giving spurious analogies — these are the well-worn methods of " pseudo-scientific and fanatic so-called spiritual and meditation groups ". If the Doctors wish to distinguish themselves from the latter, they should not adopt their methods.

Next month:



Beginning an exciting new series :

"IMPROVE YOUR MEMORY IN 10 EASY STEPS!"

Profusely illustrated with four-colour drawings, each issue of SCIENCE TODAY will feature one step — in comic-strip style — along with easy " do-it-yourself " exercises.

ASPIRIN HELPS SURGERY PATIENTS —IF THEY ARE MEN!

Surgery patients over the age of 40 are a high-risk group: they are prone to developing blood clots which could kill the patient once they get lodged in the lungs. A team led by William H. Harris of Massachusetts General Hospital, USA, has made a startling discovery: four tablets of aspirin per day prevent such blood clots — but, strangely, only in men (reported in the *New England Journal of Medicine*, 8 December 1977). Harris's team studied two groups of over-40 men undergoing hip replacement surgery — one group was given aspirin and the other, placebos, beginning a day before the surgery till several weeks after. The placebo-administered group showed a three times higher incidence of post-operative blood clotting than the aspirin-medicated group. This, Harris's team claims, is the first vigorous evidence of aspirin's protective role against blood clotting.

Women surgery patients in the same age-group failed to show any response to the aspirin therapy. Nobody seems to know why, yet! One possible explanation for aspirin's sex-selective action, Harris suggests, could be some kind of interaction between the drug and sex hormones.

THE DEAD CAN HURT

Cremation is an easy and quick method of disposal. It is a safe method, too, as it puts an end to the spread of infection and infectious germs. However, modern medical practices are likely to change the safety factor. As aids to prolonging life, often foreign objects are implanted in the body. The prosthetics include metal splints, nails, heart valves, pacemakers, etc. It is the pacemaker that is likely to cause problems in closed crematoriums, according to the *British Medical Journal* (**6103**, p. 1620, 1977).

In September 1976, zinc mercury batteries in a pacemaker left in a body exploded during cremation. (In some countries, the pacemakers are removed after death, so that they can be reused.) It was a fairly strong explosion, damaging the brick lining of the crematorium. This was the first time such a risk was recognised. Besides injuring persons at close range, such an explosion could also scatter dangerous organisms into the atmosphere.

Zinc mercury batteries are safer compared to the lithium batteries which may soon replace them. Plutonium-238-powered pacemakers of today have to pass the stringent "crematorium test" of 1300°C for one and half hours. Perhaps, the same test will now be made mandatory for other pacemakers as well.

And then there is the problem of radioactivity. The plutonium pacemakers contain up to 3 Ci (Curie) of the isotope. According to the British code of practice (1972), corpses containing up to 30 mCi of yttrium-90, iodine-131 or gold 198 or 10 mCi of phosphorus-32 can be safely cremated. The basic assumption here is that the radioactive isotope will disperse with the smoke. But there is always a danger of an explosion, fear the Federation of Cremation Authorities, which would release radioactive fumes into the crematorium; this would be harmful to the cremator.

Other radioactivity-releasing objects like needles, tubes, grains and pins containing isotopes such as radium, caesium-137 and iridium-192 are often used therapeutically. If any of these leak cremation there is no harm as the activity disperses through the stack. But when these isotopes ar in welded iridio-platinum or sta steel, the implant would survive crem and endanger the cremator.

The Federation has, therefore, ad cremation authorities to insist tha health authorities mention in the certificate whether a pacemaker o radioactive material was used by dead person and whether it has removed. If removal is not possible undertaker should be given the d so that he can take care.

NASAL DROP TO ST OVULATION

It could give a new boost to fe control. A team of Indian researchers discovered that intranasal administra of progesterone and norethisterone pressed ovulation in rhesus monke

T. C. Anand Kumar, G. F. X. David V. Puri of the Neuroendocrine Rese Laboratory at the All India Institut Medical Sciences, New Delhi, ca

THE AGING-GLAND OF THE OCTOPUS

The biography of an average female octopus of the species *Octopus hummelincki* could read thus: hatched from the egg with mechanical help from her mother. Soon orphaned, she mates while she is still immature and stores the sperm in her oviducal glands. Two weeks prior to spawning, she begins to spurn males and reduces her food intake. Before spawning, she has one set of table-manners: she bores holes into gastropod shells and injects the secretions of her posterior salivary glands, and drags out the weakened animal. After spawning, there is a marked change in the eating behaviour. She begins to forcefully pull the snail out of the shell instead of boring into it. And, also, she often does not eat the snail after removing it. As broodiness overtakes her, she loses all interest in food and she spends more time caring for her eggs. She helps out her young ones and dies — by the time they are 10 days old — just like her mother did. Perhaps, these mechanisms ensure proper baby care. The lack of appetite might act to prevent her eating her own eggs and the less time spen looking for food means she ca devote more time to her young ones.

What prompts her to fast unt death? Jerome Wodinsky of Brandei University, Massachusetts, USA, ha found an answer. The octopus has pair of optic glands that regulate it behaviour. Wodinsky removed bot the glands in some animals — both male and female — and found the lived much longer than their norma life-span. (Males generally live fo 7-9 months but there is no strong link between reproductive behaviou and feeding.) The female who ha spawned returned to her prematerna eating habits, after removal of the gland, and lived an average 175 day instead of 42 days. When only one gland was removed, Wodinsky found the female continued to care for he eggs and reduced her food intake bu lived 35 days longer.

The optic gland secretions seem to contain hormones that control sexua and parental care. Wodinsky reports (*Science*, **198**, p. 948, 1977) that jus two weeks before gonadial maturation the secretion of the gland is at a minimum and the females mate mos readily. Two weeks after spawning the secretion is at its peak and this puts an end to the sexual behaviour Removal of the optic gland reverses the pre-spawning behaviour in the female and she begins to mate again.

Though Wodinsky has shown that they don't die of starvation, he couldn't pinpoint what caused death. However in both sexes, this mechanism guarantees the elimination of old, large predatory individuals and constitutes a very effective means of population control.

out their studies between September and March when almost all the monkeys in that area had ovulatory menstrual cycles. They used adult female rhesus monkeys which had experienced at least two successive ovulatory menstrual cycles of normal duration (20-33 days). (Their report appears in *Nature*, **270**, p. 532, 8 December 1977.)

Two steroids — a naturally occurring ovarian hormone, progesterone, and norethisterone, a synthetic progestogen widely used in hormonal contraception — were dissolved in a mixture of ethanol, propylene glycol and water (1 : 1 : 3). A constant volume of this mixture was sprayed for 10 seconds into the nostril of the conscious monkey seated on a restraining chair. Controls were sprayed with the solvent alone.

The effects on ovulation were determined by measuring serum levels of oestradiol and progesterone in blood samples taken daily throughout the menstrual cycle, as well as by visual observation of the ovaries after laparotomy.

Circulatory levels of progesterone below 2 ng per ml serum together with the regressed state of ovaries at laparotomy were taken as indicative that ovulation had been suppressed.

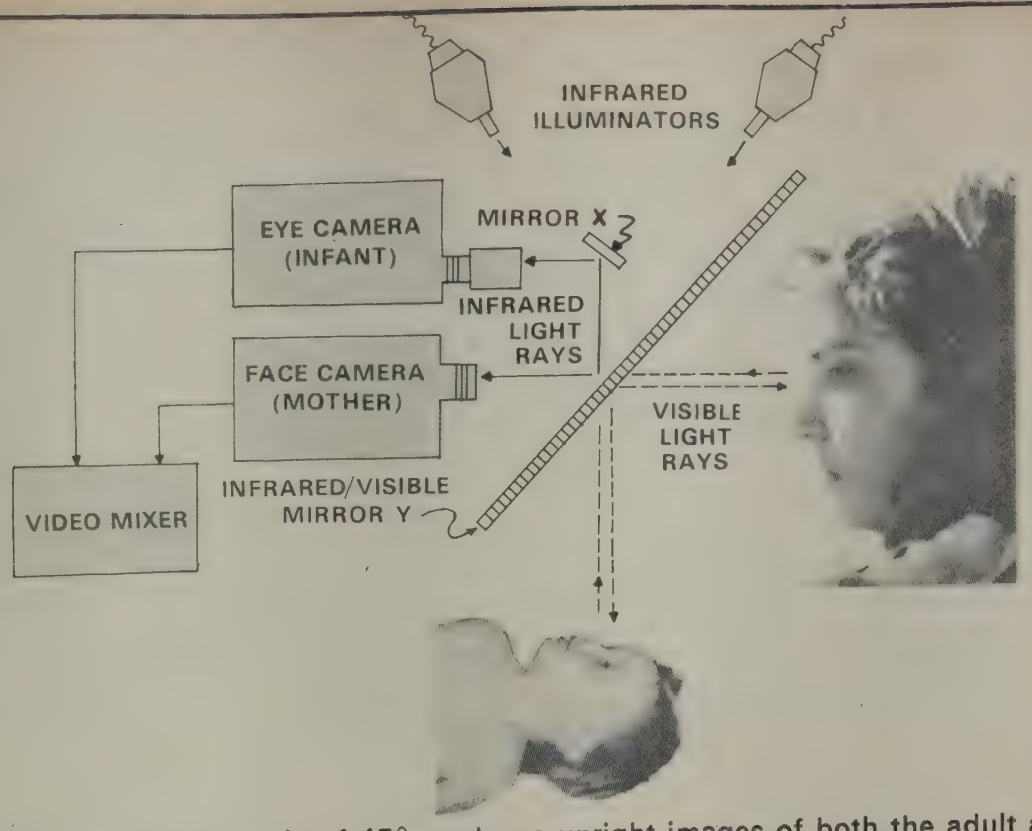
In the light of the role played by brain structures in the regulation of secretion of gonadotropins and the presence of steroid hormones in the cerebrospinal fluid (CSF), the researchers believe that delivery of steroids into the CSF ought to control fertility. And the intranasal route appears to be better than others.

ARTIFICIAL ELECTRIC FIELDS IMPROVE DRIVING

In our natural environment, we are permanently exposed to a longwave electric radiation (10 Hz) which has an almost imperceptible and yet positive influence on our well-being. This can possibly be exploited in the case of motorists. Just as people sitting inside cars are safe from lightning (since the metal body behaves like "Faraday's screen"), the metal body of a car also provides a protective screen against natural atmospheric electric fields. This may adversely affect driving behaviour. In the case of reinforced concrete buildings, blocking the natural electric field is assumed to affect human health.

A scientific team from Munich examined a number of persons in a simulated vehicle. They found that an imitation of the natural electric field reduced errors in driving. Unstable persons are influenced to a greater degree than stable persons by the artificial field.

These findings give rise to the hope that the employment of artificial atmospheric electric fields could have a favourable effect on general traffic safety—particularly in the case of tiring long-distance journeys. In other words, motorists should equip their vehicles with a type of longwave transmitter. Nevertheless, a great deal of research is still necessary in this area.



The mirror placed at an angle of 45° produces upright images of both the adult and the infant. The mother's TV camera records her face. The beams of light pass through specific points at the plane of the virtual image of the adult and converge on the infant's eye. The infant's camera records the image of the eye with the reflections of the light. Since the positions of the lights are known, the fixation points can be calculated by measuring the distance of the eye and the light (Diagram adapted from *Science*)

WHEN INFANTS LOOK, WHERE DO THEY LOOK?

That infants smile at familiar faces and fear strange ones is universally accepted. Now scientists have started asking the question, "Where in the face does an infant look?"

Marshall M. Haith from the University of Denver and Terry Bergman and Michael J. Moore from Harvard University, USA, measured infants' fixations on real faces for half-second periods and reconstructed their scanning patterns. Three to five week-old infants spent more time looking at the edges of adults' faces than at their features. In contrast, seven week-olds and nine to 11 week-olds focused much more on adults' eyes than on other areas of the faces, especially when they were talking. The expectation that talking would distract the infants from the adults' eyes was belied. Also, the experimental results did not reveal any visual preference of infants for the mother over strangers.

The ocular fixation of three to five week-olds to people's facial edges supports earlier data showing newborns' attraction to contours, the investigators say in an article in *Science* (**198**, p. 853, 25 November 1977). The suggestion that faces are seen as faces by newborns is not supported by these results. One interpretation of the shift from the edge of the face to the eyes is that in the infant's eyes, the face has changed its status from a mere collection of items to a meaningful perceptual entity.

It is highly likely that the infant's attraction for the eyes carries a special social significance for its caretakers and plays an important role in the development of the social bond. Perhaps the intensification of scanning in the eye area produced by talking signals the mother that the infant is focusing attention on her, which, in turn, encourages her to continue talking. "Further research is needed to determine if these findings are unique to voices," write the researchers.

UNDER THE ANTARCTIC ICE

What would you expect under the Antarctic ice? Few people expected to see life when researchers of the multinational Ross Ice Shelf Project punched a 420-metre hole into the ice. After blasting the hole with a jet drill, they lowered a side-looking TV camera. Soon they spotted something that looked like tiny fish; according to videotape records, the aquatic creatures were crustaceans. They lured another crustacean into a trap and fished it up.

Some scientists feel the water has been covered by ice for at least 1,20,000 years and, thus, no sunlight has ever reached there. Also, the ice-cap would have prevented any type of direct interaction with the atmosphere — this makes it a unique living environment.

The researchers have also found foraminifera — shell-bearing protozoa — as well as "worm tubes" formed by the worms living at the bottom. Bacteria account for at least 50 per cent of the biomass 20 metres above the bottom. Sediment samples showed an abundance of diatom flora — some dating back to the late Miocene period.

The water samples drawn up also indicate that some melting takes place at the bottom of the shelf. The coldest water is about half way down between the shelf bottom and the sea floor which is about 200 metres down. Monitoring the melting at the shelf bottom could tell us about the possible turnover rate of the shelf material.

MAGNETS SUPPORT BROKEN JAW

A bone-crushing automobile accident completely destroyed the upper jaw of a teenage music student. Would he never smile, eat or talk naturally again ? Thanks to an Albany (USA) dentist, Dr. William B. Smith, Jr. — and to magnet experts at the nearby General Electric Research and Development Center — the boy is back to normal.

piece prosthetic, attract each other with great force. Additional retention is obtained by slight protrusions in the front and rear of the acrylic palate, which rest on the floor of the two nostrils and on the pharynx in the back of the throat.

The magnets are so powerful that a 60 gram one can hold a 165 kg weight. It is difficult to pull apart

(Above) Fourteen supermagnets — each half the size of an aspirin tablet — are embedded in this three-piece artificial upper jaw. It consists of an upper denture and a two-piece palate, which replace the upper jawbone. (Below) The accident victim with reconstructed jaw

Why magnet experts? you might ask. The three-piece prosthetic device fitted to the inside of his mouth is held firmly in place by 14 of the world's strongest permanent magnets.

The prosthetic consists of a two-piece artificial palate, which replaces the upper jawbone, and an upper denture. The new upper jaw "works like a charm", says Gregory, the accident victim. The first step of reconstruction was to stabilise the remaining facial bones and the lower jaw. The next step was to find a suitable prosthetic device for the upper jaw: a low-weight fixture that could be easily removed and cleaned at home.

A segmented device would be required to replace the missing roof of Gregory's mouth. Dentists were at a loss how to hold it together. Cobalt-samarium magnets did the trick.

The 85 gram man-made upper jaw is believed to be unprecedented in the annals of dentistry. The 14 pill-sized supermagnets, precisely placed on the top and bottom portions of the three-

these magnets once they are attached, but they can be separated easily by sliding, a motion that does not demagnetise them. The magnets in the prosthetic may never have to be replaced. Such magnets have potential applications in aircraft and spacecraft motors and instruments, hearing-aids, biomedical devices of various types, and more powerful commercial motors and generators.

WILL IT BE TWINS?

. . . Now it's easy to say. Three Cornell University (USA) scientists, L. Jovanovic, R. Landesman and B. B. Saxena have found a quick and inexpensive method (*Science* **198**, 738, 1977). Earlier this test could be done by sonography but it is a rather expensive method. The Cornell team measures the amount of human chorionic gonadotropin (hCG) in the pregnant woman's serum. The level of hCG is known to be a good indication of the size, weight, and functioning of the placenta during pregnancy, and also of the duration of the pregnancy.

The Cornell team measured the hCG levels of 590 women four to five weeks after their last menstrual period — all were pregnant. The level of the hormone was significantly high in nine of the samples at four of the subsequent tests done up till 70 days' gestation. Pelvic examination showed that they had all conceived twins. As a control, 15 women with normal hCG levels were followed with weekly determination of the hormone level, and in this group all delivered singles.

Advance knowledge of twin conception helps to reduce fetal risk, since the physician can take proper prophylactic measures against anticipated proble
In normal pregnancies, the hCG le
rose from 1-1,000 mg/ml within 30 da
in twin pregnancy this value was reac
within 10 days. The hCG plateau occur
in both cases at 10 weeks, but the le
in twin pregnancies was almost dou
that in the normal ones.

BREAST-FEEDING— A TWIN BOON!

Breast-feeding has a suppressing effe
on fertility. Prolonged lactation protec
against pregnancy mainly by delayi
the return of ovulation. The underlyi
mechanism is believed to operate throug
the anovulatory effect of prolactin an
other hormones secreted in response
infant's suckling (see SCIENCE TODA
February 1977). Studies have also con
firmed that lactation prolongs the period o
postpartum amenorrhoea. Another sugges
tion, yet to be firmly established, is tha
breast-feeding reduces fecundability afte
the return of menstruation.

Intercourse during lactation was tabo
in certain cultures and this might b
due to the fertility-reducing effect o
breast-feeding.

John Knodel, Associate Professor o
Sociology and research associate, Popula
tion Studies Center, University of Michi
gan, USA, says in an article "Breast
feeding and population growth" (*Science* **198**, p. 1111, December 1977) tha
abandonment of breast-feeding in parts
of the world where contraception is not
in common use may mean both higher
birth rates and higher infant death
rates, especially among the poor.

The impact of breast-feeding on fertility was also assessed by comparing the length of average birth interval that would result under each feeding pattern if no contraception was being practised and assuming alternative durations of amenorrhoea associated with prolonged breast-feeding. While the average birth interval without breast-feeding was calculated to be 23·3 months, under conditions of prolonged breast-feeding and under different assumptions about its effect on amenorrhoea, the birth intervals were found to be 39, 31·6 and 26·6 months, corresponding to amenorrhoea periods of 17·7, 10·6 and 5·3 months, respectively.

Breast-feeding has another role — it checks infant mortality. Developed countries have long back recognised the advantages of breast-feeding over artificial feeding in promoting infant survival. In a study conducted in the Khanna district of Punjab in 1963, all but one of the 20 infants artificially fed from birth died within a year, compared to 12 per cent of breast-fed infants. In 15 rural communities in Chile, post-neonatal deaths among infants who started bottle-feeding in the first 3 months were three times as frequent as among those exclusively breast-fed during that time. Breast milk is nutritionally ideal for the first 6 months, provides some immunity from disease and is clean.

Infant mortality has, in fact, retarded the family planning programme.

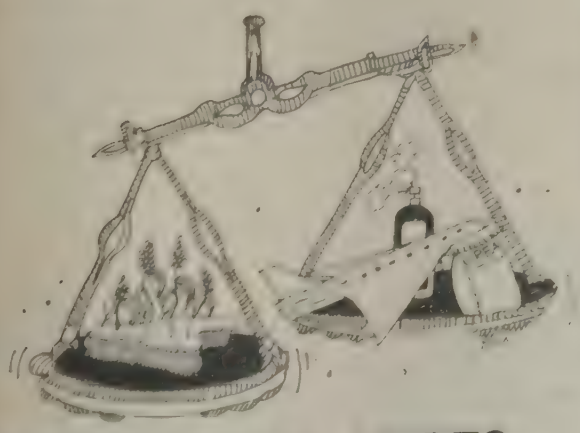
GROWING AN OZONE LAYER

The thin ozone layer in the statosphere shields the Earth from the dangerous ultraviolet radiations from the Sun. Of late, there have been several alarms and fuss that the shield is thinning due to various human activities: the exhaust gases of the supersonic planes deplete ozone; the propellants of the aerosol sprays; chlorofluorocarbons, containing the ozone-destroying chemical, and even the earthbound nitrogenous fertilisers are not exempt from the blame. However, measurements of ozone in the Northern Hemisphere seem inconsistent with this theory. Since 1920, when ozone measurements were started, there has been an increase in the ozone quantity and between 1957 and 1970 the increase was spectacular.

According to a recent report (*Nature*, **270**, p. 592, 1977), agriculture actually helps to grow the ozone layer. Dr. H. W. Ellsaesser of Lawrence Livermore Laboratory, California, USA, explains how this happens.

Plants and bacteria help in the nitrogen exchange (in various forms) between air and soil. In this process, nitrous oxide is formed. If the cycle is modified so that the nitrous oxide production drops, the ozone layer would thicken. This is what's happening, according to Dr. Ellsaesser. Nitrous oxide is produced when the soil is saturated with water, oxygen is scarce and there is much organic matter and fertiliser. When land is cultivated, this is changed. Tilling increases aeration of the soil, so also do weeding and drainage. Fertilisers are applied to porous well-drained soils in small amounts and, thus, nitrous oxide formation is reduced. Thus, the net result of agriculture is reduced nitrous oxide and hence an increase in the ozone layer thickness.

There is no reliable method to check Dr. Ellsaesser's hypothesis, however. Which means, we cannot as yet equate the increase in thickness of the layer to the acreage under cultivation.



HOST-VIRUS VIBES

Viruses are host-specific. What makes the influenza virus click with a particular host? The answer could also perhaps provide clues to a vaccine. Dr. J. Almond, virologist at the Cambridge University, UK, worked on two chicken flu viruses to see how host-specificity is determined.

One of the viruses could grow only on fowl cells and the other could be grown on mammalian cells as well. Flu viruses when grown together rapidly exchange genetic material and form hybrids. Almond grew these two together and compared the hybrids' ability to grow on different cell types. He found that this ability was dictated by a single gene. The gene specifies a protein thought to be necessary for the virus to multiply in the host cell — a protein that is compatible with the host's cell machinery that is controlled by the virus.

If Almond's results can be extended to all flu viruses, we will know why animal flu viruses attack humans: the animal virus picks up genes for appropriate protein manufacture to infect that particular host. It would also help to construct viruses for live vaccines.

RICHARD III— A VICTIM OF EXAGGERATION?

It was Shakespeare who gave king Richard III literary permanence by playing up his grotesque, hunchback wickedness, " his arm . . . like a blasted sapling, withered up : ", a " crook-back prodigy " whose " mother felt more than a mother's pain ", because, as Richard himself says, " I came into the world with my legs forward ", and had " shoulders ordained so thick, to heave ". Was Richard as deformed as the Bard made him out to be? If so, what might have been the medical diagnosis? Philip Rhodes, Post-graduate Dean of Medicine and Regional Director of the Regional Post-graduate Institute for Medicine and Dentistry, Newcastle-upon-Tyne University, UK, decided to find out. His 'hypothesis' appears in the *British Medical Journal*, 24-31 December 1977.

Shakespeare's portrayal of Richard, Dr. Rhodes points out, " suggests a premature breech delivery and a painful labour. At birth the child had a tooth or teeth, while the appearance of a toad suggests a short neck and prominent eyes. Later the child grew up to have withered arms, a hunch-back, raised shoulder, and legs of unequal length ". There are two diagnostic possibilities to match the description : Kyphoscoliosis, or some type of nerve injury affecting the arms. Dr. Rhodes rules out the former as there is no contemporary description of Richard as a hunchback. If it was a nerve injury, it could be either Klumpke's paralysis which affects the hand and part of the forearm or Erb's paralysis which affects the shoulder girdle and arm muscles. Portraits of Richard drawn by contemporary artists do not show any abnormality of the hands. Erb's palsy could be a possibility, though : Richard was an 11th child, statistically expected to be rather large-sized, which might have called for forcible traction during delivery, bringing on Erb's palsy. But, Dr. Rhodes argues, none of the historical accounts of Richard shows any weakness in either arm : he was able to wield the sword or even a battle-axe powerfully in the thick of battle.

In all probability, what Richard may have suffered from, according to Dr. Rhodes, was Sprengel's deformity in which there is an underdevelopment of the scapula. Or he may just have had a slightly raised shoulder — nothing but an exaggeration of the normal ; " every tailor knows of the almost invariable inequality of the height of the shoulders ".

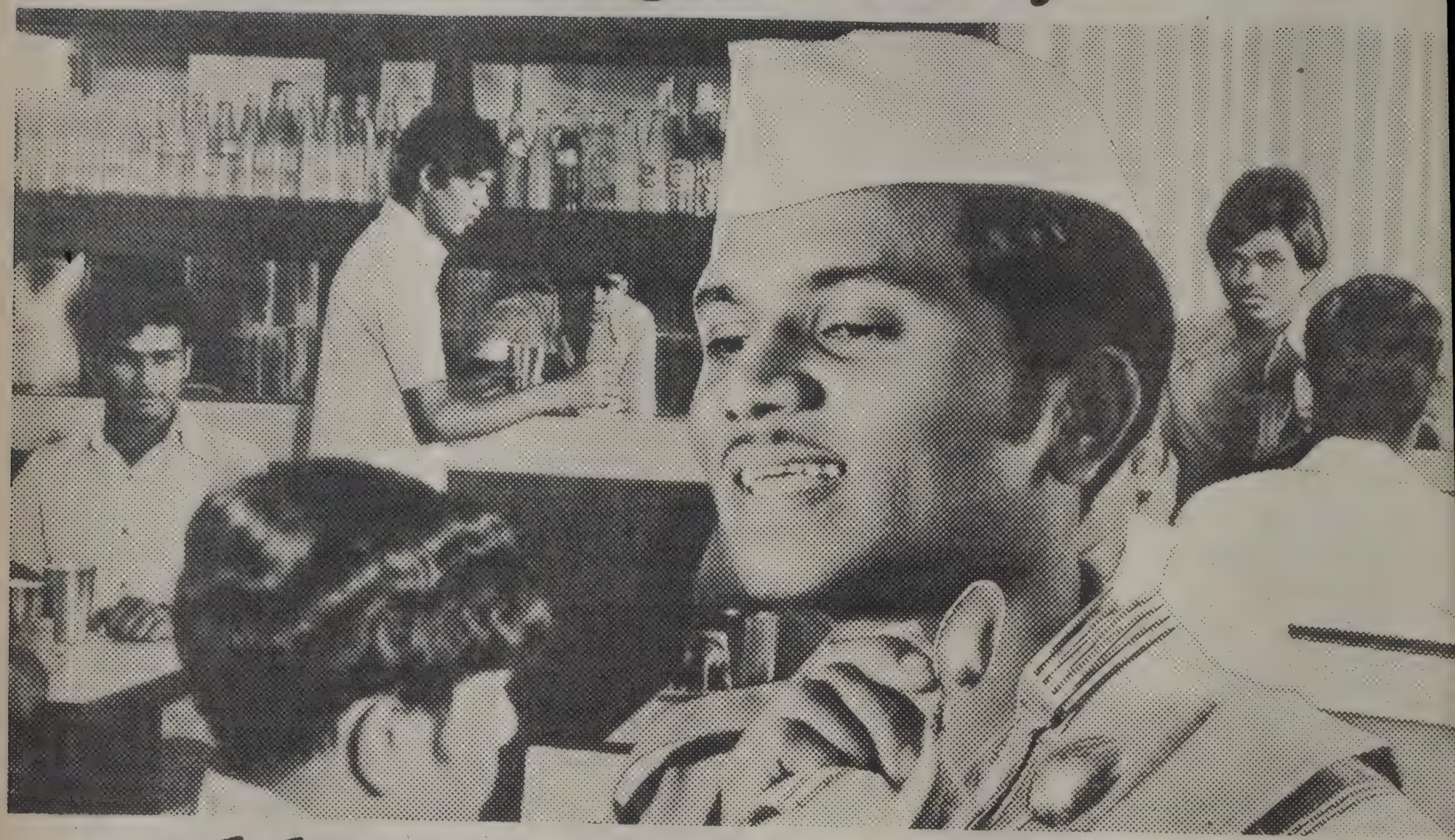
In that case, why did Shakespeare exaggerate the king's deformity? Dr. Rhodes's answer : " Shakespeare was determined to paint Richard as a villain, . . . There is a dramatic merit in making villains instantly recognisable and despicable. . . . In a less queasy Elizabethan age, physical deformity must have been a godsend to the playwright."

A SAFER TEST FOR BREAST CANCER

Mammography or X-ray of the breast used to be the test of choice until some researchers pointed out a few months back that while X-rays can detect breast cancer, they can also *cause* it. Researchers at the Memorial Sloan-Kettering Cancer Center in New York have now reported a new technique, safe as well as accurate, of measuring the difference in the thermal output of benign and malignant tumours.

Though thermal output has already been used in detection of cancer, it failed to detect early breast cancer. The new technique which gave 80 per cent accurate diagnosis of malignant tumours and 100 per cent accurate reading of benign tumours in a test involving 282 patients — uses a miniature heat detector to compare the forehead's temperature with the temperature of nine sections of each breast. The readings are taken before and after the patient dips her hands in cold water : if there is cancer, the malignant tissue remains at its high temperature ; benign tumours, on the other hand, become cooler.

"Alu-matar—Alu-gobi—Dal-fry"



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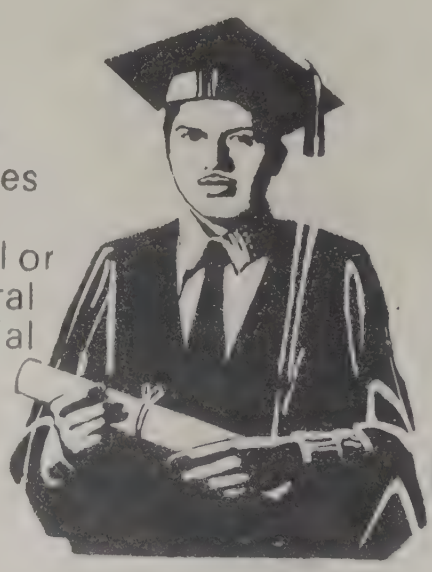

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CHAITRA-20

PHOTORESPIRATION IN PLANTS

The puzzle has been intriguing scientists for several decades: why should some green plants release carbon dioxide and take up oxygen in the presence of light, when they should be doing just the opposite via the process of photosynthesis? How does parsimonious nature tolerate this apparently wasteful phenomenon? Or, is there any as yet unknown benefit enjoyed by the photorespiring plants?

S. C. MAHESHWARI
MEENA BUDHIRAJA

PHOTORESPIRATION, as the name implies, is respiration or the evolution of carbon dioxide by green plants in light. The phenomenon has attracted much attention in recent years on two counts. One, it appears to be distinct from ordinary respiration and biochemists are intrigued about the source of carbon dioxide evolved in the process. Two, photorespiration is of vital importance from the viewpoint of economics and human welfare. It is now known that respiration in light is several folds greater in magnitude than is the case in ordinary 'dark' respiration. A question which naturally follows is, is it a wasteful process or does it confer upon the plant an as yet undiscovered biological advantange, in keeping with the parsimony of nature? If the process is wasteful — as it appears to be — evolutionists might wonder as to why it has arisen at all and whether nature is getting around to correcting its mistake!

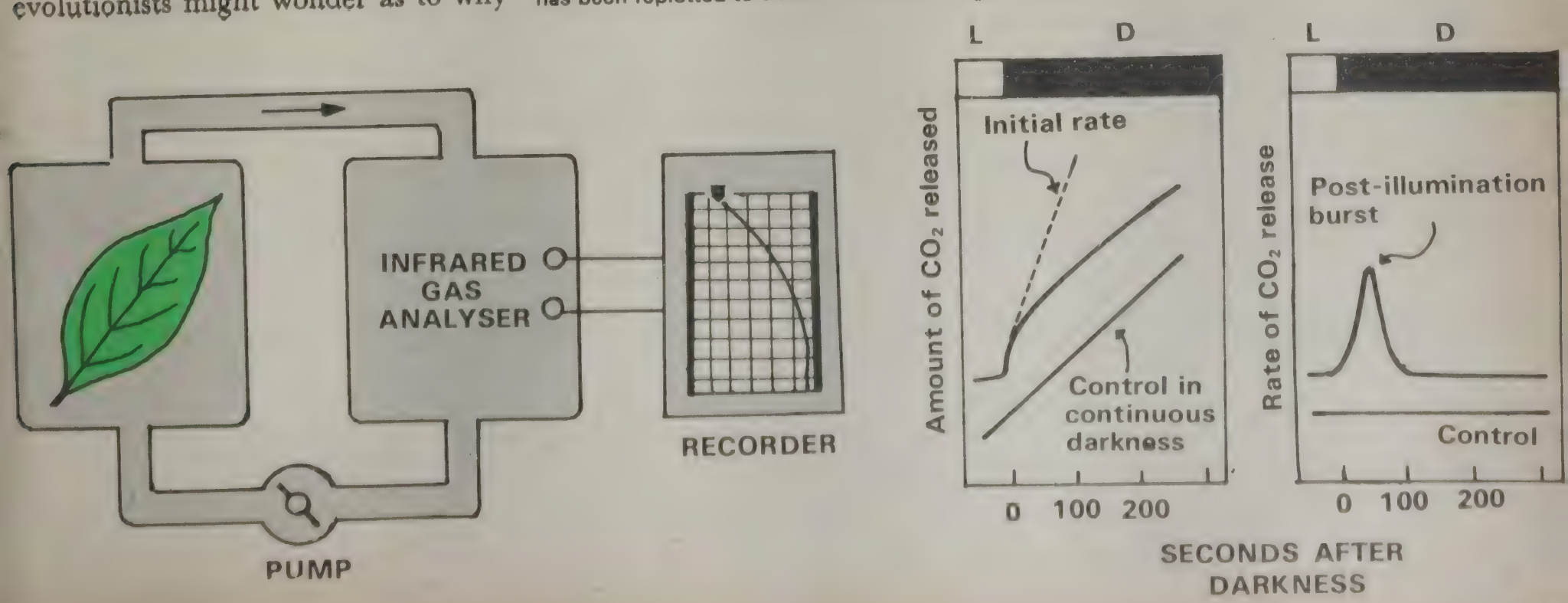
The discovery of photorespiration dates back to 1920 when the German biochemist, Otto Warburg, observed an inhibition of the photosynthetic rate in the green alga, *Chlorella*, with increasing concentrations of oxygen in the ambient atmosphere. In honour of this discovery, later scientists called it the " Warburg effect " even though they did not fully realise its significance. Warburg himself did not elaborate upon this observation and the phenomenon would have been " lost " to science but for the fact that it kept cropping up in various kinds of studies on photosynthesis and respiration and several scientists began to suspect that light did indeed stimulate respiration, at least in some green plants.

A systematic study of the phenomenon began in the early fifties when J. P. Decker in the USA discovered photorespiration in a higher plant, namely tobacco. He used the sensitive infrared gas analyser to measure the amount of carbon dioxide evolved (see Fig. 1). When plants were kept in continuous darkness, the trace by the recorder pen was more or less linear, representing a steady rate of carbon dioxide evolution. However, if plants were pre-illuminated for some time and then brought to darkness, the trace was different — it showed an initial rapid rate of evolution of CO_2 which later (within about 100 seconds) decelerated to the normal level characteristic of dark respiration. This " post-illumination burst " and its subsequent deceleration was observed in several other plants such as bean, castor and soybean. Curiously, albinos (lacking in pigment) of the above-mentioned plants showed no such phenomenon. Piecing together all these facts, Decker attributed the " burst " to photorespiration.

Apparently, photorespiration continued for a while even after light was switched off, which was presumed to be due to metabolic intermediates still present in the leaf. The fact that albino plants showed no such post-illumination CO_2 burst indicated that this phenomenon is linked to the chloroplasts. It also strengthened the view that respiration in light has a mechanism which is different from that in the dark. However, photorespiration was probably not universal since it could not be observed in plants such as corn and sugarcane.

Subsequent to Decker's studies, several other laboratories took up work on photorespiration. Ozbun and

Fig. 1 Decker's experimental set-up. The gas surrounding the leaf is circulated by a pump through an infrared gas analyser which essentially consists of a light source giving off infrared rays which fall on a photoelectric detector. When a gas, such as CO_2, absorbing infrared rays crosses the IR-beam, some of the rays are intercepted and the detector response changes. The first graph represents the trace as directly obtained on the instrument. The graph on the right has been replotted to show the rate of CO_2 evolution



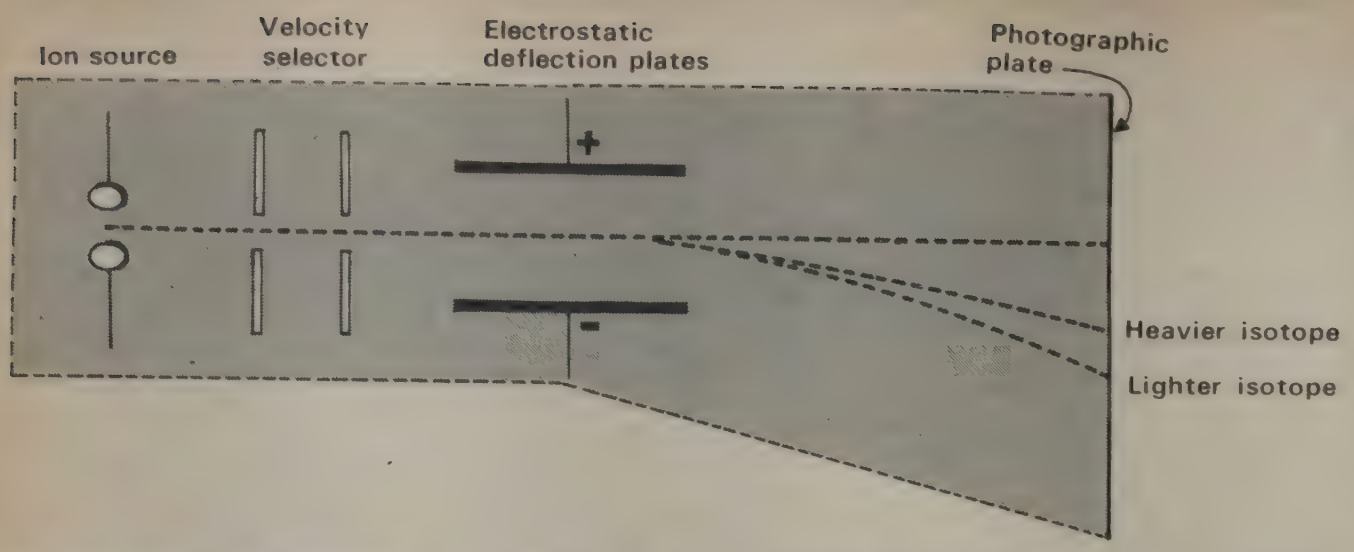


Fig. 2 Mass spectrometer is an instrument used to determine the exact mass of individual atoms. The mixture of isotopes is introduced in the gaseous form in order that all atoms are ionised. The ions are subjected to a electromagnetic field, as a result of which they are deflected. The extent of deflection can be used for identifying various isotopes present

co-workers (1964) in the USA not only confirmed the earlier work but by a modification of the technique — employing the heavy isotope of O_2, namely $^{18}O_2$ — they could observe high rates of respiration in light itself instead of relying upon the transient "post-illumination burst" as an indicator of photorespiration. They sealed the leaves of bean in a chamber, one end of which was connected to a regulated source of $^{18}O_2$ and the other to a mass spectrometer — an instrument employed for the exact determination of the mass of an isotope (Fig. 2). They observed that $^{18}O_2$ uptake almost doubled in light as compared to that in the dark (Fig. 3). This was a clear-cut evidence for the existence of photorespiration.

In the light of these observations, it is now possible to explain the inhibition of photosynthesis by high concentrations of oxygen which had intrigued Warburg in the 1920s. High levels of oxygen stimulate photorespiration, a process in which gas exchange occurs in the reverse of that in photosynthesis. As Fig. 4 shows, Forrester and his co-workers (1966) in Canada could find no post-illumination CO_2 burst in soybean leaves (despite its being a photorespiring plant) kept in 1 per cent O_2, though it could be seen readily in ordinary atmosphere, and, what's more, the burst shot up three-fold if the leaves were kept in an atmosphere of 100 per cent O_2.

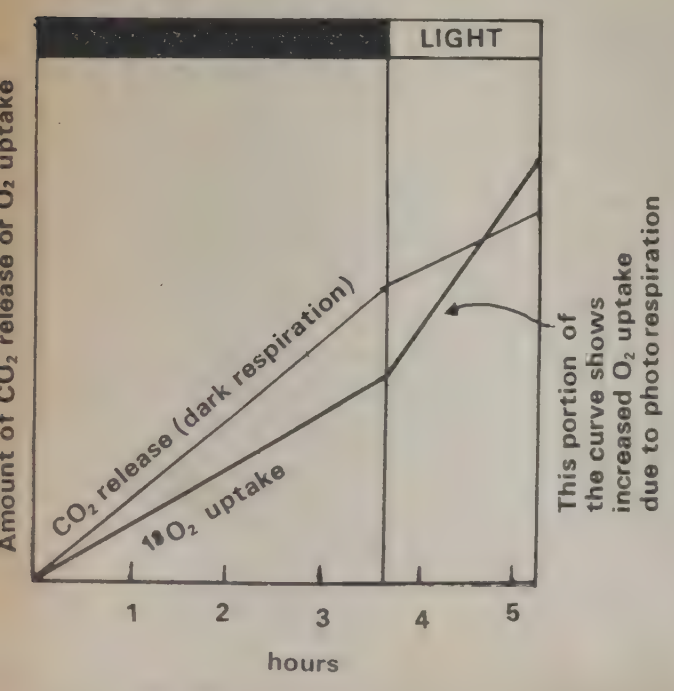


Fig. 3 The difficulty of measuring respiration in light arises from the fact that any CO_2 released is quickly utilised for photosynthesis. Thus, instead of an increase (due to photorespiration), release of CO_2 registers a decrease. Enrichment of the atmosphere by $^{18}O_2$, however, enables one to clearly observe a stimulation of respiration in light (After Ozbun *et al*, 1964)

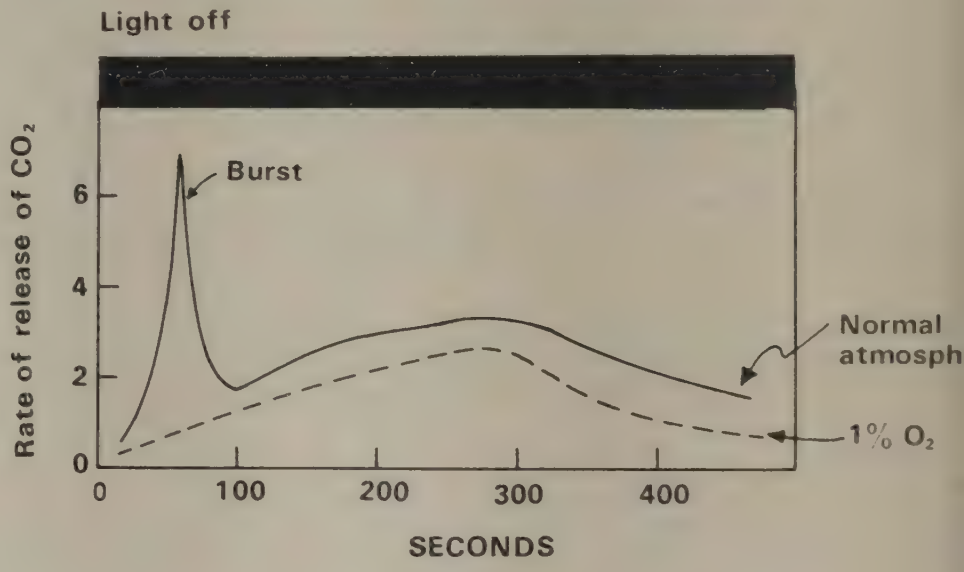


Fig. 4 The effect of O_2 concentration on t "post-illumination burst". The solid li shows the response in 21 per cent O_2, that normal atmosphere, and the dotted line sho the response in 1 per cent O_2 (After Forres *et al*, 1966)

Biochemistry

Photorespiration differs from dark respiration in another aspect: whereas in dark respiration the substrate is generally considered to be a sugar (Fig. 5), in photorespiration glycolic acid (a 2-C organic compound) serves as the substrate. This acid was first detected by the famous American biochemist, Calvin, in his Nobel-prize winning work on the pathway of CO_2 assimilation and was found to be labelled among other products (such as phosphoglyceric acid) during short-term exposures of plant material to $^{14}CO_2$. The realisation that it serves as a substrate for photorespiration came gradually when a number of experiments showed that the conditions favouring photorespiration also fa the formation of glycolic acid. example, it was observed that gly acid accumulated with increase o concentration in the atmosphere. same effect could be obtained decreasing the ambient CO_2 con tration.

There have been a number speculations over how glycolic ac synthesised in the plant cell several explanations have b offered. The latest, and now more less generally accepted, is the given by the American work Bowes, Ogren and Hageman (19 Indeed, they have unravelled a curi double role played by the enzy RuDP (ribulose 1–5 diphospha carboxylase. Ordinarily, the enzy catalyses the fixation of CO_2 as result of which two molecules phosphoglyceric acid (a 3-C co pound) are formed from one molec of RuDP (see Fig. 6). Interesting under conditions of a high O_2/C ratio, the enzyme RuDP carboxyl is unable to catalyse this CO_2 fixatio instead, O_2 successfully competes wit CO_2 and the RuDP carboxyla switches to oxygenase activity. Whe this happens, RuDP is cleaved to for a 2-carbon phosphoglycolic and a carbon phosphoglyceric acid (Fig. 7

The phosphoglycolic acid forme in the RuDP oxygenase reaction easily converted to glycolic acid, whic then acts as the substrate for photo respiration. The subsequent meta bolism of glycolic acid follows a com plex pathway (Fig. 8) involving mor than one organelle during its meta bolism — an essential feature of th pathway is that while some of th carbon atoms of the glycolic acid mole cules are respired away as CO_2, othe return to the chloroplast to become

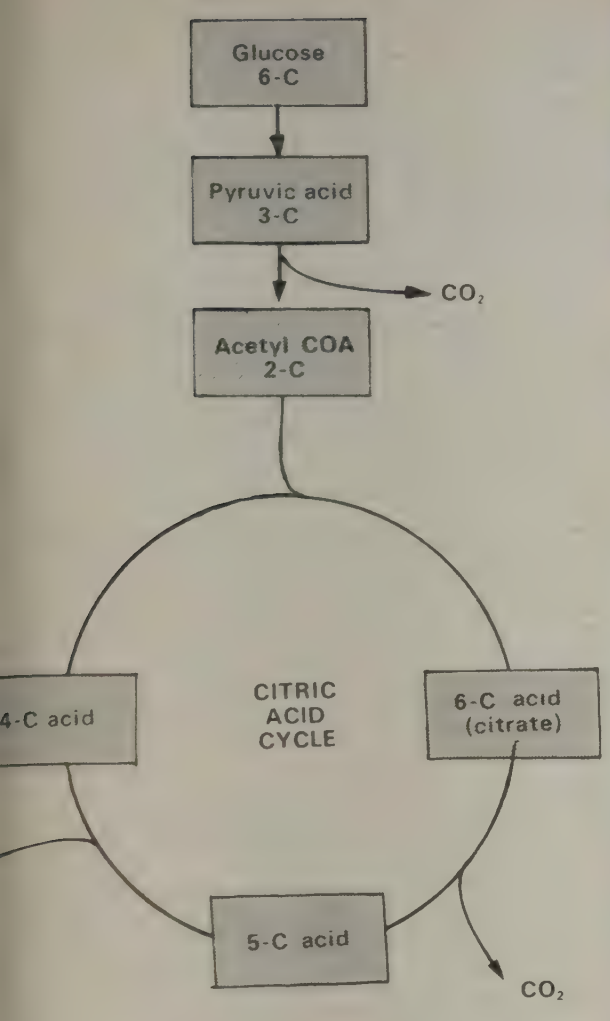


Fig. 5 Simplified scheme of the pathway of CO_2 evolution in normal respiration (removal of hydrogen atoms and generation of ATP not shown). This is the way sugar molecules are broken down in cells of all living organisms including those in the non-green parts of plants

part of the Calvin cycle. The unravelling of this pathway by Tolbert (1971) in the USA is in itself a major achievement of plant biochemistry.

The pathway shown in Fig. 8 is supported by several observations. If labelled glycolate (wherein the carbon atom of the carboxylic group is labelled) is fed to a photosynthesising plant, the label appears first in glyoxylate and glycine (both 2–C compounds), then in serine and hydroxypyruvate, and finally in phosphoglycerate, all of which are 3–C compounds. It is thought that carbon dioxide is liberated when two molecules of glycine join to form serine. This pathway is validated also by the discovery of the various enzymes involved. For example, the enzymes which catalyse the conversion of glycolic acid to glyoxylate and of glyoxylate to glycine have been located in the glyoxysomes. However, glyoxysomes do not appear to be the site of CO_2 evolution; this is believed to take place in the mitochondria. The next two enzymes of the pathway, that is, one which converts serine to hydroxypyruvate and the other for the reduction of hydroxypyruvate to glycerate, are, however, found exclusively in the glyoxysomes; one must suppose, therefore, that these 3–carbon compounds re-enter the glyoxysomes before phosphoglycerate (containing the "salvaged" carbon atoms) appears in the chloroplasts.

About the Calvin Cycle

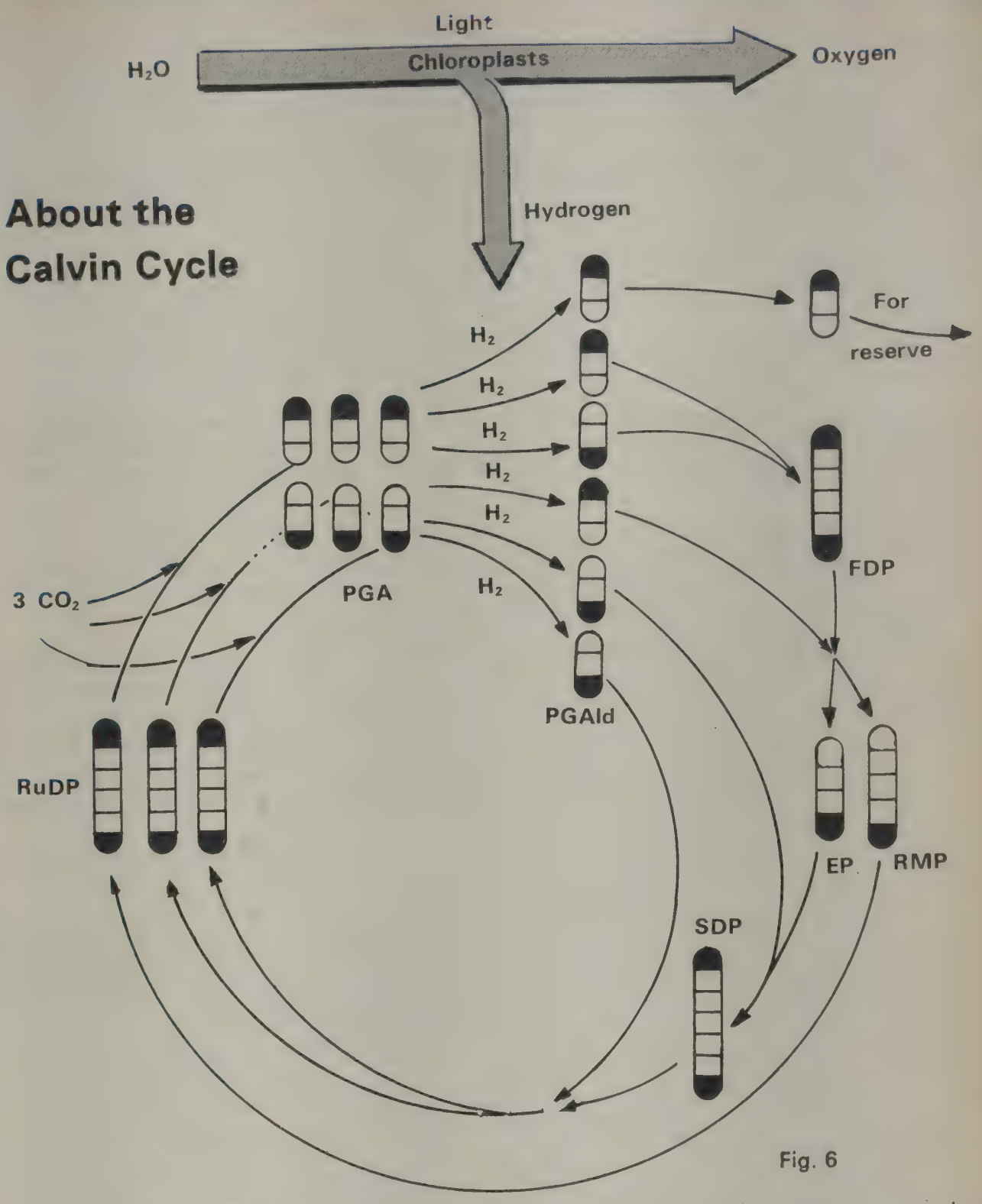


Fig. 6

Photosynthesis is a highly complex process. Broadly, however, it may be said to comprise of two types of reactions, that is, those requiring light and those that do not. In the light reaction, energy captured by the chlorophyll molecules is used for the splitting of water into oxygen and hydrogen. The oxygen produced is given off as molecular oxygen whereas the hydrogen is accepted by a hydrogen acceptor which then provides for the reduction of the molecules of carbon dioxide entering a leaf from the atmosphere.

The capture of carbon dioxide molecules, and their further transformation, however, are all dark reactions. Three of these molecules combine with three acceptor molecules of a 5 C, phosphorylated sugar, called RuDP. The intermediate is short-lived and splits up immediately to form two molecules of the 3-carbon compound, phosphoglyceric acid. At this point, use is made of the hydrogen acceptor (from the light reaction mentioned earlier) to reduce the phosphoglyceric acid molecules to phosphoglyceraldehyde. The reduced 3-carbon molecules then combine to form the ordinary 6-carbon sugars which may in turn transform themselves to reserve carbohydrates or to fats or to proteins. However, an essential part of the photosynthetic reaction is the regeneration of RuDP, the CO_2 acceptor. This is accomplished through the Calvin cycle, named after the discoverer of the cycle. The reactions of the cycle may appear to be rather complex. But, in essence, of every 6 molecules of phosphoglyceric acid formed, only one is available for formation of sugar — the remaining five recombine through a series of steps to return the three molecules of RuDP with which the reactions for capture of CO_2 are initiated. Thus, the entire cycle becomes self-sustaining and the reactions go on as long as there is light.

The Calvin cycle is represented here in terms of the number of carbon atoms in substances which are taking part in the cycle. The blackened parts of the molecules represent carbon atoms to which phosphate groups are attached. Abbreviations: FDP, fructose diphosphate; EP, erythrose phosphate; RMP, ribose monophosphate; and SDP, sedoheptulose diphosphate. It may be added that the regeneration of the sugar ribulose in its diphosphate form requires energy-rich phosphate bases from ATP. The ATP molecules are a by-product of the main light reaction whereby water is split into hydrogen and oxygen. However, for simplicity the mode of generation of ATP is not shown here.

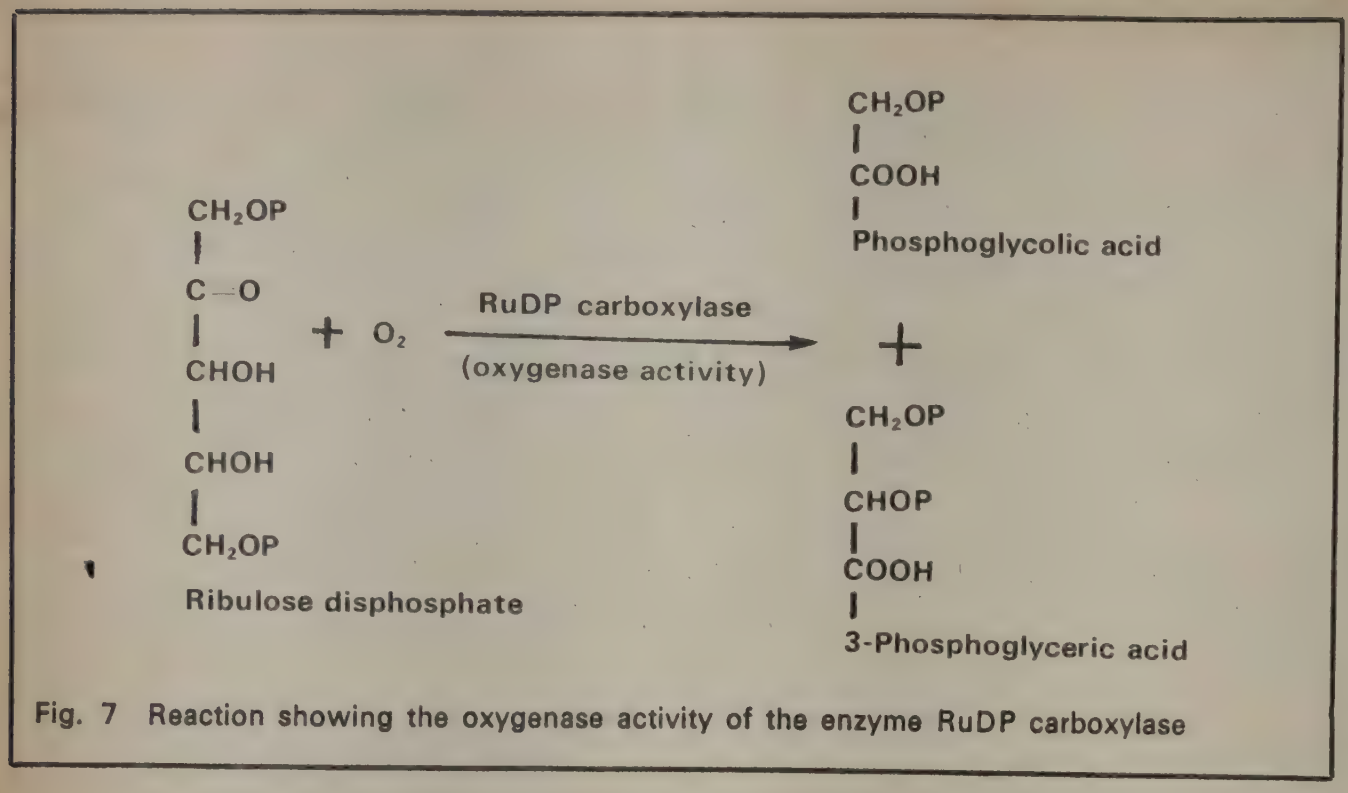


Fig. 7 Reaction showing the oxygenase activity of the enzyme RuDP carboxylase

thus introducing CO_2 into the Ca cycle whereas the unlabelled fragment returns to the enzyme carboxylase to enable it to ac another CO_2 molecule from the mosphere. As already mentioned, bundle sheath cells have some Ru carboxylase and there may very be some photorespiration. Howe the CO_2 so evolved would be presu ably recaptured by the surround cells through the enzyme PEP c boxylase.

As is well known, the basic feat of normal "dark" respiration is generation of ATP (adenosinetriph phate) molecules which provi energy for all the processes taki place in the cell. We must point o

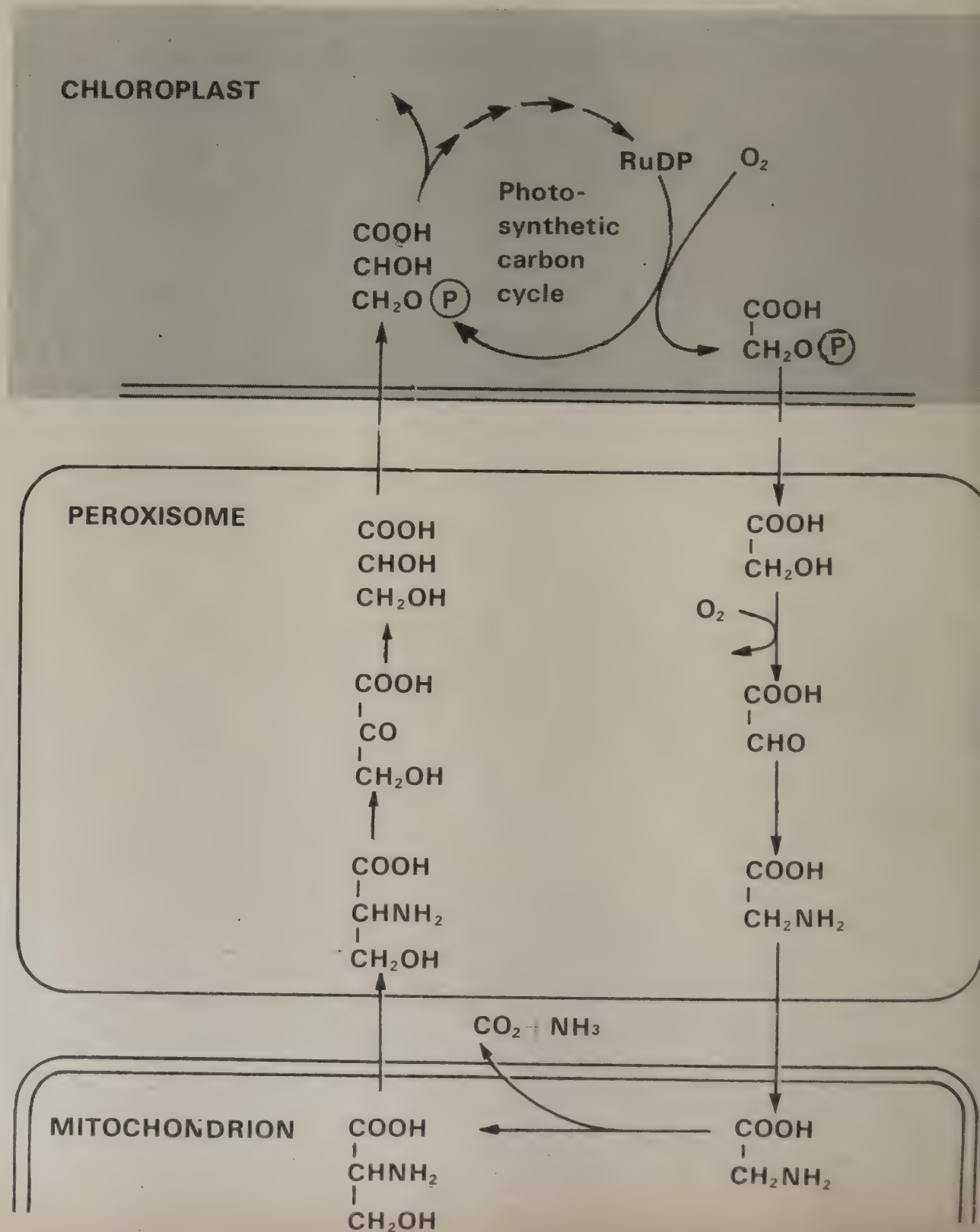
C-4 plants avoid photorespiration

Having learnt about the intricacies of glycolate metabolism, let us now turn to a basic question: What happens in plants where there is no apparent photo-respiration? Have they altogether done away with this phenomenon which is very possibly an encumbrance? If so, in what way? Well, this leads us to another discovery of great interest. In contrast to the usual Calvin cycle plants, in the non-photo-respiring plants the RuDP carboxylase is confined to thin inner layer cells around the vascular bundles (see Fig. 9). Assimilation of CO_2 is carried out by a new enzyme, PEP (phosphoenol pyruvate) carboxylase, which is far more effective than RuDP carboxylase. PEP carboxylase catalyses the capture of CO_2 by phosphoenol-pyruvate as a result of which a 4–C acid is formed. However, beyond this point, the fixed CO_2 molecule follows the same path as in the usual Calvin cycle plants. The 4–C acid interacts with the RuDP, the regular acceptor,

SOME COMMON EXAMPLES OF PHOTORESPIRING (C-3) AND NON-PHOTORESPIRING (C-4) PLANTS

PHOTO-RESPIRING C-3	NON-PHOTO-RESPIRING C-4
Wheat	Corn
Rice	Sugarcane
Legumes	Sorghum
Potato	Sugar-beet
Tomato	Bajra

Fig. 8 A simplified scheme indicating the reactions involved in glycolate metabolism and their intracellular sites. Only the oxygen activity of the enzyme RuDP carboxylase is shown, which results the formation of glycolic acid. These molecules move out, through cytoplasm, to a newly discovered organelle called peroxisomes glyoxysomes which convert glycolate to glyoxylate and then to glyci which then moves into the mitochondrion. Although *photorespirat* CO_2 is ultimately believed to be liberated from mitochondria, as c be readily seen by a comparison with Fig. 5, this mechanism of respi tion is quite different from that normally obtained in mitochondria



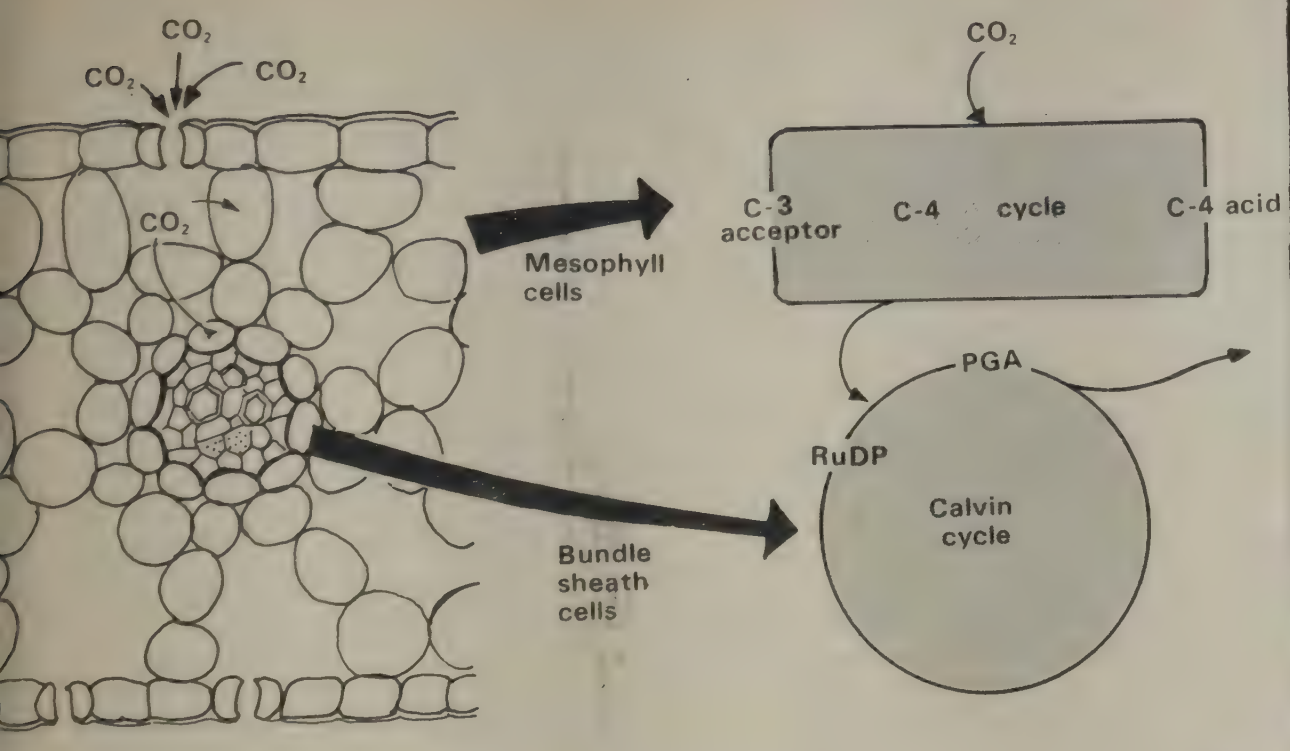


Fig. 9

The C-4 cycle plants

The diagram illustrates the anatomy of plants which apparently do not photorespire, and the C-4 pathway of carbon dioxide fixation with which they are endowed. Here, CO_2 is captured initially, that is, from the atmosphere by the enzyme PEP carboxylase, instead of by RuDP carboxylase in the Calvin cycle plants, which are these days often referred to as C-3 plants since the first product of CO_2 fixation in this cycle is the 3-carbon phosphoglyceric acid rather than oxaloacetic acid. If some photorespiration does occur in the C-4 plants in their bundle sheath cells, the CO_2 so released would probably be recaptured and cycled back.

however, in the glycolate metabolism (photorespiration) there is no gain of energy; rather, there is a loss of ATP (when glyceric acid is converted to phosphoglyceric acid; refer to Fig. 8). In that case, we might as well ask: of what possible advantage is the glycolate metabolism to the plant? There is as yet no satisfactory answer to this question. However, if we regard the formation of glycolic acid as something which is unavoidable (as a consequence of RuDP oxygenase activity), its subsequent metabolism may be viewed as a mechanism for salvaging at least one other PGA molecule. The PGA is of course recycled in the Calvin cycle and can contribute to the formation of sugar.

From all accounts, photorespiration, as now understood, does appear to be a wasteful phenomenon, both from the economic angle as well as for the plant. The fact is that, despite the glycolate metabolism which returns some of the carbon from glycolic acid back to the Calvin cycle, photorespiring plants are estimated to lose as much as one-third of the total carbon fixed through this process. Many of our important crops, such as wheat, rice, barley, tobacco and soyabean suffer this disadvantage. Understandably, this phenomenon has become the subject of active research in many laboratories the world over, with several directions of research. Some scientists wish to find an inhibitor that will block photorespiration. Others want to convert C-3 plants into C-4 plants by methods of genetics and plant breeding. Still others are going into the intricacies of the phenomenon in the hope of finding as yet an unknown benefit to the plant and thus to humanity.

Dr. S. C. Maheshwari (43) is Professor and Head of the Department of Botany, Delhi University. After obtaining his PhD from Delhi University (1958), he did post-doctoral research at the Yale University, USA, as Smith Mundt-Fulbright Fellow (1959-60), and then at the California Institute of Technology, Pasadena, USA (1960-61). He was at Harvard as a Homi Bhabha Fellow during 1973-74. He was awarded the S. S. Bhatnagar Award in 1975.

Meena Budhiraja is a Junior Research Fellow working with Prof. Maheshwari.

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IN LIGHTER MOMENTS

THALES of Miletus, reputed as the founder of Western philosophy, was also an astronomer. Once, while walking in the street at night, he was so engrossed contemplating the stars that he fell into a ditch and injured his knee. An old woman who pulled him out of the ditch told him that he must have been a liar when he claimed knowledge of heavenly bodies, because he could not see even what lay at his feet.

* * *

BESIDES being a physicist, Einstein was also a great mathematician, but he himself didn't seem to be very sure of his maths. While he was living in Berlin, the English painter and writer, Sir William Rothenstein, did his portrait. During several sittings the artist found "a solemn-looking individual" always quietly sitting in a corner of the room and occasionally nodding or shaking his head in response to some theory or problem put forth by Einstein. At the end of the sittings, Sir William asked the scientist who that man was and was surprised to learn: "That's my mathematician. He examines problems which I put before him and checks their validity. You see, I am not myself a good mathematician."

* * *

DENIS Papin, the 17th century French physicist, pioneer of the steam engine and inventor of the pressure cooker, ambitiously planned to drive a ship with a steam engine. Failing to get any aid or encouragement from his patrons at the University of Marburg, he decided to go to England.

He purchased a boat and fitted it with paddle-wheels, which were to be later driven by steam power. To dramatise the whole thing, he propelled it by means of hand-cranks and wanted to go all the way to England with his several children and their mother aboard.

But Papin had gone hardly a few kilometres out when watermen stopped him. In the ensuing tussle, the watermen pulled the boat up on the land and broke it to pieces. And the poor scientist had to reach London 'desperate and without a penny'.

* * *

ISAAK Newton as a boy was not much good at jumping or running and once decided to skip a sports meet. But it so happened that in spite of his best efforts he could not give it the slip and had to participate. However, a kind of scientist's intuition helped him. When he entered the field, he found a gusty wind blowing. He lost his nervousness and "timed [his] leaps to take advantage of the gusts and won the event."

S. N. MUNSHI

SOME THOUGHTS ON INDIAN SCIENCE...

Last September, portions of the introductory remarks made at the meeting of the newly-constituted National Committee on Science and Technology by its new Chairman, Dr. Atma Ram, had caused a minor flutter. Where time is of the essence, Dr. Atma Ram had said, buying a patent is buying time; instead of reinventing and rediscovering in the name of self-reliance, India should better utilise time, effort and investment to improve and build on the available technology.

At the same meeting, the Prime Minister, Mr. Morarji Desai, detailed the NCST's function as the "principal advisory body to the Government . . . to help in formulating and implementing Government policies in science and technology."

With this pre-eminent role of the NCST in mind, we had requested Dr. Atma Ram to elaborate on some of the views he has been expressing from time to time, as part of the "informed public debate on this country's science policy and its plan priorities" which SCIENCE TODAY had begun last month with the publication of the anniversary address by Dr. Raja Ramanna, President of INSA, and extracts from the Prime Minister's speech at the NCST meeting. Dr. Atma Ram's replies to some of the questions we had sent him, are reproduced below, along with relevant extracts from his NCST address . . . .

[*At the outset, Dr. Atma Ram disagrees with the expression "science policy":* I think the expression "Science Policy" is something of a misnomer. To the scientist, science may be an end, but to the layman, science represents a powerful tool for progress. The massive support governments are giving to science is not so much for the pursuit of science for its own sake, but in the hope of benefits that could accrue from such pursuit. So a policy for science, in real terms, is a policy for the application of science. We have a Science Policy Resolution which was adopted by the Government two decades ago. It extolled science of the high-yielding variety. It did not, however, spell out a policy for the farming of science to produce tangible results, economically or socially.]

You have said that science policy can be viewed only in the context, and as part, of an integrated national planning. Why?

A policy for the application of science, in essence, is a technological policy. It involves the laying down of objectives and operational choices — priorities in the context of resources, constraints and the contemplated rate of progress. Therefore, a policy for the application of science has to be integrated with national planning.

Would you say that national planning is a product of modern scientific culture? Isn't it governed by the political objectives the community has clearly set for itself? Say, like the Chinese or earlier the Japanese and the Russians did to set as their goal the attainment of the status of an independent centre of power?

National planning is a necessity for a developing country like India where resources are limited, problems are manifold, and time is of the essence. I do not think that national planning is a product of modern scientific culture. Scientific attitudes, methods and approach are very important in any planning, much more so when planning on a national scale. National planning is essentially an exercise for achieving social advancement. The possibility of national planning has emerged as a result of the application of scientific methods to socio-economic processes. It is obvious that first the objectives should be defined and the goals set. Then alone can the priorities be laid down.

You have said that a developmental strategy for India should consist of three essential elements: (1) comprehensive survey of our physical resources and their exploitation; (2) encouragement to capital formation and enterprise; and (3) development of human resources.

Can you elaborate on how these have been neglected so far?

It is only recently that significant attention has been paid to a systematic study of our groundwater reso and of the natural resources espe of our frontier and offshore Although considerable amou work has been done in the fie geological survey, much remai be done in the matter of soil s which is of great importance fo agriculture. Optimum utilisati resources can be effected only proper location, mapping and a ment.

Capital is obviously necessar the utilisation of resources. E measure has to be taken to encou domestic savings. The tax struc should encourage savings, and excessive expenditure.

Compared to most other develo countries of East Asia, literacy India has lagged behind. Thi particularly so in the matter of a literacy. This acts as a deterren even average productivity by workers. Our industrial developm has not capitalised so much upon native skills as on imported tech logy. The strength of a na depends very much on the excelle of its skilled craftsmen and technici While institutional provisions at post-graduate, degree and diplo levels have made progress, our p grammes for training men on the j and upgrading their skills, have m scant progress.

When you say the problem has to looked at in its entirety and all questi need to be brought together within ambit of an integrated national po statement on technology, can you iden the areas where failures have occurred

We have been talking for long abo smallscale industries. Some, whi

■ An apex advisory body of th Government like the NCST should no in my view, get entangled in considerin individual research projects an schemes, reducing itself to a sort of research committee. Nor should it ge involved in updating the annual plans sectoral or otherwise, which the COST and the earlier NCST, had done fo historic reasons like having a Chairma with official responsibilities of planning. Science and technology permeate inextricably vast areas of our national activity. We have the Planning Commission to take a total view of the situation. Two advisory bodies of the Government should not be engaged in covering the same ground. It will be for the NCST to provide the necessary perspective, and suggest priorities, in the areas of science and technology to assist in an early accomplishment of governmental objectives.

—Extract from Dr. Atma Ram's NCST address on 29 September 1977

ere flourishing at one time in the nallscale sector, have been practical- wiped out. This was not always due largescale production being cheaper an production by the small scale, ut often because of the greater sources and marketing arrangements f the largescale producers. If we had well-defined policy regarding the noice of technology, this need not ave happened.

In one of your lectures, while stressing he importance of availability of raw naterials in determining a technology olicy, you stated that we enjoy competitive dvantage in areas like jute, textiles, tea, tc, and we should have given concentrated ttention to problems related to these ndustries and used the best techniques. Can you elaborate?

Textiles, tea and jute used to be among our top export earners. Even marginal improvements would have greatly added to their profitability and international competitiveness, which we have now lost. Research on tea, and on lac, was largely done outside the country, but was substantially financed by India with little benefit in return. Our textile industry has tended to remain technologically stagnant. The unique position achieved in the export of textiles by Hong Kong, which is not even as large as an average district of India, is simply amazing.

You say, in spite of all the incentives, research by industry is not growing fast. What, in your opinion, could be the reason?

Much of our industry has been developing in a protected market, making research expendable. More recently, however, there has been a substantial increase in the R & D expenditure in industry; annual reports of many companies carry long passages on R & D. Impediments in the prompt utilisation of indigenous R & D results, and the dependence upon foreign collaborations, have also had their impact on the slow growth of R & D in industry. The erroneous impression that local R & D and import of technology are mutually exclusive has also contributed to the confusion.

Can you identify the fields in which the country should seek and obtain know-how?

Whether a technology for a particular production should be acquired or not depends upon the prevailing situation and the anticipated advantages. For instance, cement is being produced in the country for decades. Fuel is a substantial item of cost in cement manufacture. Any technology which can reduce the consumption of fuel should be welcome. It is reported that the Japanese have developed a method of producing cement in which there is a substantial reduction in the consumption of fuel. Should we not consider such a technology attractive?

"Modern technology", you say, is capital-intensive and labour-saving. Conditions in India are just the opposite. The test for which technology should be selected should be suitability to our needs rather than superiority, so as to avoid create social imbalances and unemployment. Do you have in mind the "Green Revolution"?

I am in favour of technologies which reduce the burden of unemployment. But the technology to be adopted should not ignore efficiency, quality and competitiveness. It hardly needs stressing that capital-intensive technologies have a tendency to increase social and economic disparities.

I do not know how far one is justified in calling the recent spurt in agricultural production a 'revolution'. The name "Green Revolution" does make this development appear spectacular. The discovery of penicillin has not been commonly called a "Drug Revolution", which actually it was: an absolutely unique class of remedies based on an entirely novel principle was introduced, which led to a new approach to surgery and therapy.

You say, we should have the very best in sophistication in such fields as steel-making, basic chemicals, defence and health. Can you give examples of areas where high degree of sophistication was sought in this country although it was not necessary?

Perfumes, cosmetics, toothpastes, beverages and several processed foods.

■ Indigenous R & D and import of technology are not mutually exclusive. They are complementary. We need far more intensive efforts in R & D in areas in which technology is borrowed so as to adopt, modify, and improve with the least possible delay. It is not the acquiring of technology which is bad as such, but the way we have done it that has done us harm. We almost isolate and insulate ourselves, and in the process become dependent, and even subservient, on the technology donor. Borrowing must not end in perpetual bondage.

Japan, USSR and even China are buying technology in a big way. The most important thing is in the choice of suitable technology, and in its acquisition on the most profitable terms. We are not a technologically illiterate nation. Our experts can be depended upon to make the best available choice, and build upon it, provided they are suitably utilised. There need be no question of ideology in the acquisition of technology — from the East or the West, right or left.

The prestige and profitability attached to a variety of good products with the stamp "Made in India" should be more important to us than the credit of "Invented in India" on a few. Prosperity comes from production, not merely from discovery or invention. The emphasis should be on self-reliance in manufacture, in economy, and in competitiveness, but not necessarily in working out every process and product ourselves as some seem to imply when they talk of self-reliance. Every suitable technology available in the country must be preferred and fully utilised. National interest should not be compromised, even in cases where a technology has to be borrowed, in the event of its not being available in the country. One simple criterion should be to leave out what we can afford to do without, as in the case of many consumer products.

Measures for minimising the baneful influence of restrictive privileges like trademarks and proprietary names, which have hampered the normal development of R & D, and its utilisation, have to be given careful consideration.

Toothpastes, soft drinks, cosmetics and other articles of the type have been very much in the news recently. Who will accept today that Indian scientists cannot work out formula for these articles of everyday consumption? As a matter of fact, there can be any number of variations. But they have little chance of survival in the market in competing with well-established internationally known brands. This again is a problem of love for swadeshi.

Basic research is essential for building up scientific capability, supporting industrial development, and for major breakthroughs. With the soaring cost of research, even affluent countries like the USA have had to adopt measures for diverting inputs into selected areas, and slowing down work in others. It may appear amazing that in spite of such a multitude of research schemes in operation in our country, little work on certain important areas like tea, jute and leather is carried out in institutions other than the laboratory particularly devoted to it. How can our talented young scientists be exposed to the pressing problems of relevance to the country?

It is not always a question of lack of knowledge, expertise or research. What is needed often is action in putting available knowledge to use. In the field of health and medicine, there is any amount of established knowledge which we have failed to use and which could provide succour to millions.

—Extract from Dr. Atma Ram's NCST address on 29 September 1977

Which are the projects you consider to be merely prestigious and not of any social or economic importance?

There can be differences of approach in considering a project as prestigious. As far as I am personally concerned, fields like radio astronomy, genetic engineering and a good deal of space and particle physics have more prestige value than economic or social relevance in the India of today.

You have spoken of excessive departmental democracy and how it impedes work. Can you elaborate?

The clamour for departmental democracy is inversely proportional to the eminence and quality of leadership of the professor, or laboratory director. If the leader is not engaged in research, and is merely attending and holding conferences, meetings, etc, I doubt if he can inspire confidence in his colleagues. They would gladly accept an eminent researcher as their leader. They accept his authority for his standing in science, not necessarily because of his administrative powers which they may often resent. A hierarchical potentate thrives on internal committees, panels and the like — all in the name of alleged internal management. The result is obvious — decay. A true director or professor guides and builds up the younger members of his team. Some of them may even excel him. Under the inspiring leadership of Prof. Arnold Sommerfeld, an eminent physicist, younger colleagues like Wolfgang Pauli and Max von Laue attained great eminence and won Nobel Prizes though he himself did not.

When it comes to choosing the proper man in administration of science, what will be your criteria for selection?

It is not easy to lay down criteria for selection of administrators for science departments. One finds out people after giving them some trial. The impression that scientists do not make good administrators is wrong. I believe that scientists on account of their training can have a more practical approach to problems of administration. It is not that all scientists make good administrators. Sometimes a specialist, being too much of it, can be an impediment to proper administration rather than an asset.

You have said that no important decision should be taken without consulting the scientific societies? What societies do you have in mind?

It will be good for important matters of scientific interest if the views of concerned scientific societies are invited. The Indian National Science Academy was recognised by the Government as the premier scientific society in the country more than three decades ago. There are a number of other leading academies, scientific societies and professional bodies. They should discuss democratically the scientific and technological implications of current developments, whether formally referred to them or not, and convey their recommendations to those concerned, including the people. They should generate national consciousness and aid in arriving at correct policy choices. The ultimate deci must, of course, rest with the deci makers.

You advise purchase of suitable tec logy from abroad without comprom national interest and crippling local eff Can you name some of these technolog

It is not possible to name tech logies which should be imported should not be imported. It depe on the situation and the anticipa advantages. Careful consideration to be given to economic and politi implications, apparent or otherw

You ask for competition in Ind industry. Does it also mean competi with multinationals?

I do not rule out competition Indian industries with multinationa They are all selling their goods in t same market. Uneven competiti which may prove ruinous to indig nous effort has to be prevented appropriate policies.

If scientists and industrialists have be working at cross-purposes so far in t country, can you suggest modifications the present linkages to improve the situatio

Indian scientists and industriali are *not* working at cross-purpose There is, however, some hiatus betwe the scientists and the industrialist It is a question of attitudes an approach. As I have said on anoth occasion, R & D in India is chara terised by misplaced expectations an overenthusiastic claims. More ofte than not, neither the scientists no the industrialists seem to fully appr ciate the role and function of eac other. The industrialists expect to much from research laboratories. A one scientist put it, " It is too muc to expect from industrial researc laboratories not only to plant th research seed of a product, to make grow into a tree, to harvest the frui but also to chew them and feed ther into the mouths of industrial com panies".

Can we say what hampers progress is lack of (i) *a clearly enunciated list of ou national priorities;* (ii) *good preliminar work in the chosen areas before it is decide either to develop the process indigenously or import the technology for a limite period to accelerate development;* (iii) *body to compel use of technology so develope by the industry, both private and public* (iv) *expert panels to continuously evaluat progress in different fields in relation to th country's needs and developments;* an (v) *a desire to assimilate the technolog culturally through a modified system of mas education and by using past local experience in the field?*

I have often said, if you have correctly identified the problem, you

■ The extent to which our educational system in science and technology is conducive to the rapid attainment of our national objectives also needs consideration. What is the contribution of our universities, IITs and other prestigious institutions to the development of science and technology of relevance to rural areas, or to the generation of rational attitudes? How far are they involved even in the development of educational technology to tackle the problems of illiteracy and ignorance in the countryside? In our technical education we have tended to keep the standards of the developed countries in view, not the needs of the developing countries.

■ The numerical strength of our qualified scientific and technical personnel poses its own problems. Continued unemployment of persons educated at great cost represents wasted resources and social discontent. The problem of brain-drain represents the other end of the spectrum. The dwindling opportunities for our scientific personnel in the developed countries, and the expanding demand for technical personnel in the Middle East, are likely to lead to severe strains in the science and technology set-up in the country. How do we propose to meet the situation as it emerges? On the one hand, we are advocating job-oriented education; on the other hand, we are putting a premium on advanced degrees. How do we reconcile these?

■ The question of autonomy of scientific institutions is raised from time to time. Intellectual autonomy in the pursuit of the set objectives and identified programmes is very important and must be fully ensured. But it may be difficult to concede the demand for autonomy in the unquestioned exercise of authority, or freedom from accountability. Scientists in key positions have every responsibility to ensure that the resources placed at their disposal are used to the best national advantage. A climate of trust and self-discipline has to permeate our science and technology establishments.

—Extracts from Dr. Atma Ram's NCST address on 29 September 1977

■ There is much to be gained from the expertise and experience of the developing countries in the field of cottage and village industries. Exchange of skilled craftsmen and artisans on lines similar to the exchange of scientists could be mutually beneficial. This could be a very practical way of increasing profitable co-operation among developing countries. We have yet to adopt this practice even among craftsmen from different parts of the country.

—Extract from Dr. Atma Ram's NCST address on 29 September 1977

ave half solved it. Laying down of ational priorities is extremely import-nt for mobilising our resources and chieving quick progress. Before a echnology is imported from abroad, good deal of work must be done in he country. In fact, we should already e strong in local R & D in that particular field. Unfortunately, there has been an erroneous impression that where there is R & D in the country, we need not import technology, and where technology is imported, there is no need to bother about local R & D. Local R & D and import of technology are complementary and not mutually exclusive.

There is no need to have a special body to compel the use of technology. Any institutional structure to compel the people, whether in the public or the private sector, will be counter-productive. There are already a number of institutional agencies — licencing committees, Foreign Investment Board, Directorate General of Technical Development, etc.

There should be special " cells " to keep track of the important technologies in India, and those practised in other countries. In this task we should involve our universities, national laboratories, and other research organisations. There is no such arrangement at present. These " cells " should evaluate the progress made, as also the changes in technology, so as to make industry efficient and competitive.

We have been running industries for many decades; there has been great advancement in higher technical training. We have been using sophisticated machines. We have, however, not created in our people what I would call *machine sense*. And this brings in the problem of technicians. While I was unemployed after completing my doctoral work at Allahabad, I joined a sugar factory as an unpaid apprentice. It was during this period that I learnt a valuable lesson. I had learnt much about crystals, but I did not know how to grow a sugar crystal. This I learnt from a sugar technician without formal education who used to grow crystals in large vacuum pans. After learning the technique of crystal-growing from him, I applied some of the ideas of chemistry to the process and the two of us together — the skilled technician and the scientist — did much better both in quality and quantity. I had a similar experience while we were working on optical glass at the Central Glass and Ceramic Research Institute, Calcutta. We had a very ordinarily educated potter in the laboratory. He was of great help in making pots of big size, and sometimes made valuable suggestions. We must enthuse our scientists with the spirit of mastering skills and not merely considering skills to be the job of mistris and operators.

Dr. Atma Ram (70), Chairman of the reconstituted NCST, obtained his DSc from Allahabad University in 1936 and in the same year joined the Indian Industrial Research Bureau which later developed into the CSIR in 1942. In 1945, he was assigned to organise the Central Glass and Ceramic Research Institute in Calcutta. By 1952, he had become its Director. Dr. Atma Ram's work on optical and coloured glasses has received world-wide attention.

Dr. Atma Ram was the first recipient of the S. S. Bhatnagar medal (in 1959). In 1966, he became Director General of the CSIR.

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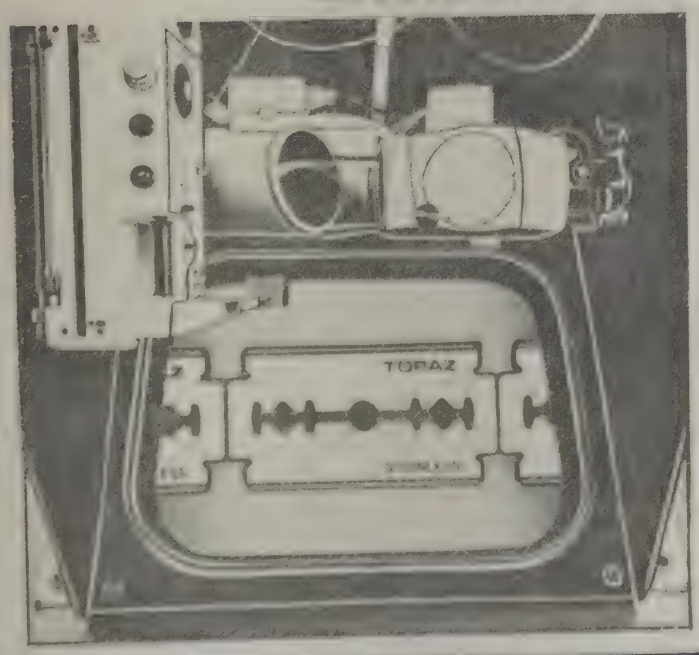

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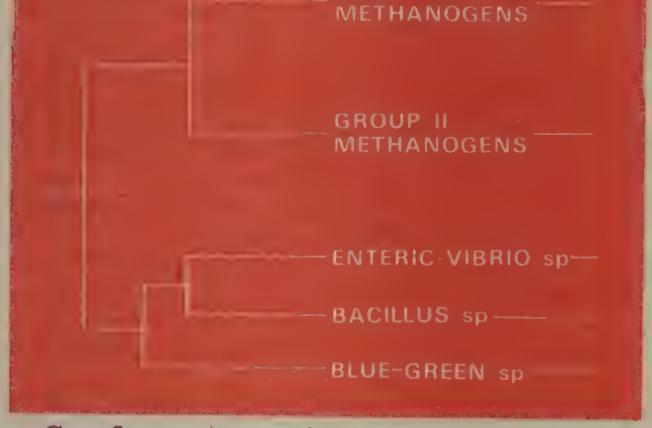
EVOLUTION

The Oldest Form of Life

RECONSTRUCTION of the story of the evolution of living forms is an exciting scientific enterprise. Biologists divided the living world into two groups, prokaryotae (mainly bacteria) and eukaryotae (plants and animals) since their cells, the basic units, differ from each other strikingly in complexity and organisational detail. The nucleus, the main hereditary apparatus, is bounded by a membrane in the eukaryotic cell, but the prokaryotic organism has an unbounded nuclear body. In addition, eukaryotic cells, in general, possess organelles like mitochondria, which have not only their own DNA and RNA but also the ribosomes, all of which are more akin to the respective components of prokaryotes rather than those from eukaryotes. Similarly, chloroplasts, the seat of photosynthesis, of the eukaryotic plant cell have their own DNA, RNA and ribosomes that are like those of the blue-green algae. The implication, then, is that a eukaryotic cell is a composite which arose from a primeval engulfing species which took in some prokaryotes and lived symbiotically ever after.

Under the circumstances, should the eukaryotic cell be directly compared to the prokaryotic one? Not so, say Carl Woese and George E. Fox (*Proceedings of the National Academy of Sciences*, USA, **74**: 5088, 1977) and they argue that because of the composite nature of a eukaryotic cell they must first be reduced to phylogenetically separate components which in turn may have arisen from non-composite ancestors. Thus, phylogenetic groupings must be formulated from amongst non-composite species, meaning the prokaryotes. It is important to determine how eukaryotes evolved. Was it from a prokaryote? And did this happen often? Woese and his group have, however, addressed themselves primarily to the structure of the prokaryotic domain. Comparing amino acid sequences of proteins or nucleotide sequences of a nucleic acid is useful in determining phylogenetic relationship. None of the easily identifiable and characterisable proteins fill the bill but ribosomal RNAs (rRNA) are ubiquitous. Moreover, the primary structure of several 16S RNAs is known; ' S ' is the size of the molecule. The 16S rRNA has a sequence that changes very slowly with time. Thus, it can provide a yardstick for relatedness amongst species.

To determine relatedness amongst bacteria, G. E. Fox, L. J. Magrum, W. E. Balch, R. S. Wolfe and C. R. Woese (*Proceedings of the National Academy of Sciences*, USA, **74**: 4537, 1977) compared the extent of sharing of short nucleotide-sequences that were produced from 16S rRNA by digestion with a certain enzyme. By applying the technique of comparative oligonucleotide cataloging to methanogenic bacteria, Fox and co-workers have obtained a very surprising result. They found that the methanogenic bacteria appear to be quite distant from other micro-organisms such as the blue-green algae. They suggest the interesting possibility that methanogens may be the most ancient branching off in bacterial evolution and that they could be older than even the ' gerontocratic ' (origin about 3 billion years back) blue-green algae.



So far so good, but what else is there to support this notion? Fox's team suggests the consideration of the following points: (*i*) Metabolism of methane production is highly unique. Coenzymes M and F420 appear to be peculiar only to methanogens; (*ii*) Cytochromes (electron transferring proteins) or quinones (electron-carrying coenzymes) have not been detected in methanogens; (*iii*) Methanogen cell walls do not contain a prominent constituent peptidoglycan that is present in all other bacteria except halophiles; and (*iv*) Methanogen transfer RNAs (tRNAs) lack the so-called " comm sequence " (ribo) thymidine-p douridine-cytidine-guanosine. D sion I of methanogens has the k sequence pseudouridine - pseudo dine - cytidine - guanosine and divi II uridine - pseudouridine - cytid guanosine.

Fox and his co-workers point that three of the four points are related to production of methane the requirement of a strictly anae bic niche. The tantalising possibil as suggested by the authors, is t methanogens may have existed a time when the earth was rich carbon dioxide and hydrogen and not have oxygen, in which case met nogens may have played an import role in our planet's physical evoluti

From the rRNA sequence analy Woese and Fox feel that there three very early lines of descent presented by (*i*) eubacteria includi all true bacteria (gram-negati gram-positive and blue-green alg and chloroplasts, (*ii*) the archa bacteria containing methanoge bacteria and (*iii*) the urkaryo represented by the mitochondrion in eukaryotic cells (Urkaryotes is t name suggested for a hypotheti group, ancestors of the eukaryote Did all the three putative desce arise from a common ancestor? If what was the nature of this ancesto Since eubacterial and methanoge lines have been stable for 3-billion more years, it would appear that t ancestor had a relatively short time branch out. Woese and Fox conjectu that this entity was probably ev simpler than a prokaryote and evolv faster. Whether this turns out to correct or not, the work of Woese a his group constitutes an important st towards getting a picture of the ve early biotic evolution.

N. K. NOTAN

[Dr. Notani heads the Genetics Section in t Biology and Agriculture Division, Bhab Atomic Research Centre, Trombay.]

ASTRONOMY

Two Suns in the Solar System?

OVER 50 per cent of the stars in our galaxy, the Milky Way, are members of binary or multiple systems. Is there a possibility that the Sun, too, has a companion? This proposition was first raised in the 1960s. Recently, E. R. Harrison has revived the idea (*Nature* **270,** 324; 1977) in the light of observations of five pulsars which seem to be grouped together in the same part of the sky.

Pulsars, which have now come to b reliably identified as rotating neutro stars, are accurate clocks; the arriv time of successive signals (the perio from pulsars is remarkably constan With the passage of time the perio gradually lengthen. That is, the pulsa slow down. The group of the fiv pulsars, it is found, are running dow at an extraordinarily slow rat Harrison attributes this abnorma feature to the acceleration of the Sola System towards the five-pulsar cluste And the acceleration is supposed to b due to the hitherto undetected com panion of the Sun.

What could be the nature of the companion star? The companion probably has a mass of the same order as that of the Sun and could be located some thousands of AU away (one AU—astronomical unit—is equal to the distance between the Sun and the Earth: $1 \cdot 495985 \times 10^8$ km). It could be one thousand million times less bright than the Sun; it could be a 'black dwarf' which failed to ignite its nuclear fuel or a 'white dwarf' that has cooled down to a surface temperature of a few hundred degrees Kelvin during the lifetime of the Solar System; either of these is too faint to be detected. The companion could not, however, be a neutron star or a black hole which need a violent explosion for their formation; such an explosion would certainly disrupt the weak bonds of the binary system. However, a neutron star (or black hole) could be passing in the neighbourhood of the Sun in an open orbit. Such an object can be detected only by its gravitational influence on its environment. Whatever the nature of the object, it must be located in the same plane as the Solar System. If not, it would disturb the planets out of their orbits which they seem to be closely adhering to.

A companion star should produce noticeable long-term effects on the Solar System, particularly on the climate and motion of the planets. But the Sun's companion, if there is one, has not produced any measureable effects. The orbits of comets are also liable to be influenced by the companion and it may even help explain how the cometary cloud, which is supposed to extend to about 1,00,000 AU, is captured by the proposed binary system.

Though a companion star has not been detected by any of the present-day techniques, there is no reason to exclude the possibility of its existence.

There is another way, not discussed by Harrison, by which the Sun might acquire a companion. This could happen if Jupiter, which just missed becoming a star, turns 'on'. There is evidence that Jupiter radiates more energy than it receives from the Sun. Could it then be relying on its own energy store? The giant planet, now 300 times as massive as the Earth, is supposed to be increasing throughout the history of the Solar System by capturing matter from the interstellar regions as the system moves around the Galaxy. It is also being continuously bombarded by the wind from the Sun. Such accumulation might lead to sufficient increase in its mass to trigger off the nuclear reaction and then Jupiter would be a star in its own right. When this happens, we can truly say that the Earth has become a planet with two Suns provided, of course, it survives in the company of its bright relatives.

S. M. CHITRE

[Dr. Chitre is with the Theoretical Astrophysics Group at the Tata Institute of Fundamental Research in Bombay.]

ENTOMOLOGY

Chemosterilisation of Insects

CHEMICALS which cause sterility in insects have long been under study. Chemosterilants reported thus far include alkylating agents (Tepa, Metepa, Apholate, etc), derivatives of phosphoric triamide and s-triazine, and antimetabolites, etc; most of these cause sterility in males and some in females. But these are quite hazardous chemicals that adversely affect living cells, causing chromosomal aberrations, lethal mutations, etc. Even certain nutrients, for example, biotin, have been observed to cause sterility in the females of certain insects.

In a recent report (*Nature*, **270**, 1977, p. 512), B. P. Saxena and co-workers (Regional Research Laboratory—CSIR, Jammu Tawi) discuss the induction of sterility in the female red cotton bug (*Dysdercus koenigii*) by the vapours of the oil of the rhizome of the plant *Acorus calamus*. The oil vapour caused failure in the production of oocytes (unfertilised eggs) or induced their resorption, if already formed, in the ovaries of *Dysdercus*. Earlier studies had reported the induction of sterility in male houseflies by the vapours of the same oil.

Another category of chemicals reported to induce sterility in insects is the insect growth regulators (IGRs). IGRs include chemicals which mimic juvenile hormones of insects or antagonise them. About a decade ago, scientists had reported the induction of sterility in the females of *Pyrrhocoris* bugs by a juvenile hormone mimicking compound. Such a sterility resulted from the sterility of the eggs produced rather than due to inhibition of formation of eggs or their resorption.

More recently, a chemical constituent of the plants of the genus *Ageratum* was reported to cause sterility in the females of several insect species by preventing development of oocytes (SCIENCE TODAY, June 1976, p. 11). The active chemical, Prococene II, was believed to act antagonistically to the natural juvenile hormones which are necessary for the activation of the growth of ovaries in insects. Such an antigonadal action of the Prococene II was later reported in the cockroach.

In the background of the above-mentioned facts, the observations of Saxena and his co-workers reveal that the vapours of the oil of *Acorus calamus* cause sterility in the females of *Dysdercus* by inhibiting the formation of oocytes or their resorption. (Almost similar effects by the classical chemosterilant, Metepa, on the same insect have also been reported.) In this context, Saxena and his co-workers say that the effects of the oil vapours of *Acorus calamus* are specific to the ovaries, in contrast to the general non-specific adverse effects caused by other classical chemosterilants; the authors report that the oil vapour did not affect the larvae (3rd, 4th and 5th instars) which developed and moulted normally. These workers have also shown the relationship between the

(Left): The ovary of a six-day-old *Dysdercus* treated with *Acorus* oil showing a well developed germarium of oocytes. (Below): The longitudinal section through the ovariole of the treated ovary

molecular structure of the major chemical constituent, β-asarone, of the oil of *Acorus calamus* and the sterility in the insects. They report that β-asarone is neither a juvenile hormone mimetic substance nor does it inhibit the natural juvenile hormone activity of the insect. Nevertheless, *Acorus calamus* oil has been previously reported to show insecticidal properties as well.

Considering the present state of our knowledge, the most appropriate chemicals for sterilising harmful insects for their control appear to be those which have low toxicity and mimic insect juvenile hormones (3rd generation pesticides) or antagonise the latter (4th generation pesticides).

K. N. SAXENA

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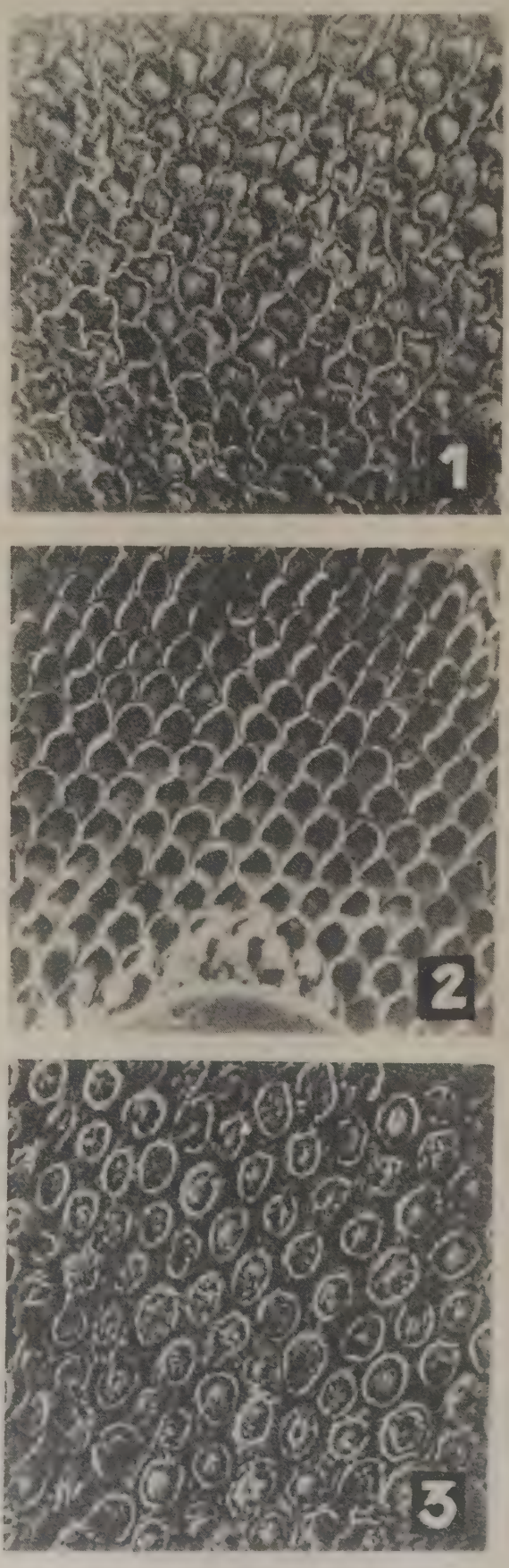
ANTHROPOLOGY

Sighificance of Hominoid Enamel Prism Patterns

A TEAM of palaeoanthropologists, Dr. David G. Gantt of Florida State University, Dr. David Pilbeam of Yale University and Dr. Gregory P. Steward of Southern Illinois University, USA, have recently carried out scanning electron microscopic studies of enamel prism patterns of some hominoid teeth. (Enamel is the hard, calcified and glossy material that covers the exposed surfaces, the crown, of teeth and may extend to the roots.) Their results, if substantiated further, will provide a major support to the theory of the evolution of man. The new findings (reported in *Science*, **198,** 4322, 1977) are all the more important since, till recently, the studies on the ultrastructure of dental enamel in mammals, including man, had received scant attention, except for some preliminary work done earlier. With the advent of scanning electron microscope, studies on the development and ultrastructural features of enamel gained momentum. Apart from helping us to understand better the structure of enamel in mammals, the recent work of Dr. A. Boyde on developing and mature enamel has shown that enamel prism patterns could be used as a taxonomic indicator.

Teeth are generally the most abundant and profusely collected remains of animals. Most discoveries of fossil primates (the group embracing man, half-apes, apes and monkeys), especially the hominids (man or man-like creatures), are based on dental finds. It is now realised that mere morphological studies of the hominoid teeth do not provide much data on phylogeny; they do, of course, help in the correct identification of a species.

For a detailed appraisal, Drs. Gantt, Pilbeam and Steward studied the enamel prism patterns in a select sample of primate teeth, particularly of the Hominoidea. A number of premolars and molars collected from various extinct and extant species were cleaned in absolute alcohol and acetone for one hour each. Later they were etched in a 10 per cent solution of hydrochloric acid for 2·5 minutes to remove the outer prismless layer. The specimens were then washed in distilled water and dried in air for an hour, before being glued on to aluminium stubs with a silver conductive compound. Subsequently, they were again air-dried and mounted with one of the surfaces of the cr facing the electron beam. (They coated with 100Å of carbon 150Å of gold to ensure comp coverage of the specimens to pro an even conductive coating.) specimens were examined in a s ning electron microscope at var magnifications and photographe



Scanning electron micrographs of the enamel prism patterns of (1) human teeth, (2) Ramapithecus teeth and (3) pongid teeth

The enamel prism pattern in *H sapiens* (the species to which belongs) was found to be well d mented and is described as a keyh pattern. In the case of pongids which gorilla, chimpanzee and ora utan belong), the enamel pr pattern was found to be either circu or hexagonal. The above meth was also applied to a fossil homin specimen of *Ramapithecus punjab* collected along with hundreds vertebrate fossils in 1922 by the Dr. Barnum Brown from the Chi Formation of the Siwalik Group (n in Pakistan) — a formation that 12 to 14 million years old. (*Rama thecus* is now generally accepted being the precursor of mankin This specimen, a right lower mol lay unknown in the Americ Museum of Natural History for m than half a century and came light only recently when it correctly identified. The enamel pri pattern of this tooth was found to similar to the keyhole pattern chara teristic of *Homo sapiens*. Thus, for t first time, it has been shown th the enamel prism patterns of t pongids and hominids can be eas differentiated.

The generally accepted view th *Ramapithecus* is ancestral to lat hominids seems to get further suppo from this study. The teeth of *Ram pithecus* exhibit thick enamel and hominid-like prism pattern. As right stressed by the researchers, it important that more hominoid tee be examined to note the function significance of the prism patter and the enamel thickness which w be very significant eventually f phylogenetic and taxonomic purpose Besides, the prism patterns obtaine by this method are reproducible an the method itself is non-destructiv It may be recalled that anatomic comparisons between man and ap and studies on the chemical structu of their proteins (SCIENCE TODA March 1976, p. 16) have also estab lished a close resemblance betwee man and apes. This has now bee substantiated by the study on th enamel prism patterns.

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HEALTH HAZARDS IN TEXTILE INDUSTRY

f you smoke three-quarters of a igarette or travel 100 km by car or 50 km by air, or do rock climbing or 90 seconds, or work in a factory or 10 days, or simply live to be a nan aged 60 for 20 minutes, well ! – you run a " one-in-a-million " risk f death. Sounds funny? It was neant to be. That cheeky dig was nade by Sir Edward Pochin of the JK who terms both occupational nedicine and numerical assessments of risk a " faculty and a ascination ".

Sir Edward notwithstanding, there sn't anything funny with the scientist's fascination with occupational hazards, especially where the risk happens to be very much more than ' one-in-a-million '. Take, for example, the textile ndustry in India. Today it employs nearly 1 ·5 million workers, of which over 8,00,000 are in cotton textiles alone. Now, consider, about 20 per cent of textile mill workers in India are victims of byssinosis, a disabling respiratory disorder caused by inhalation of cotton dust. That makes the risk one-in-five !

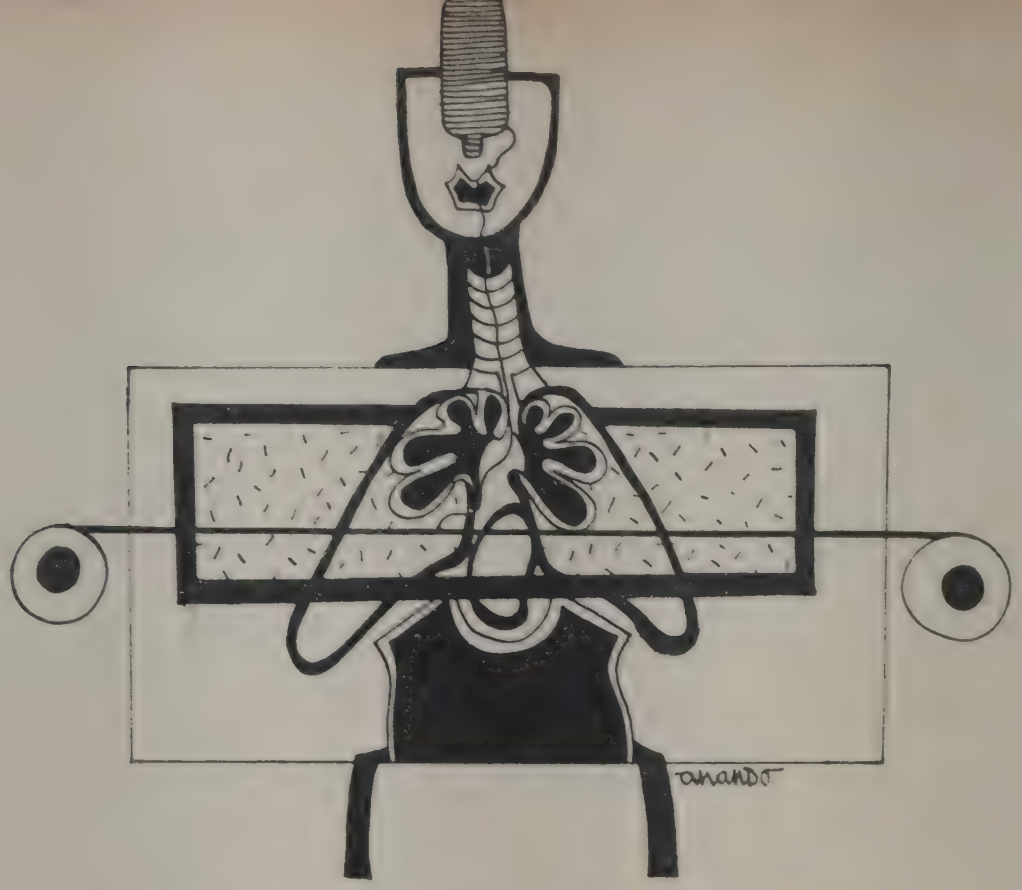
Besides the ubiquitous cotton dust, there are the dyes and chemicals so widely used in textile mills. It is now known that several of these emit toxic vapours and mists which bring about changes in the chemistry of the blood and the brain, apart from the well-documented skin disorders caused by prolonged exposures.

Textile mills have to operate in a humid environment, often artificially induced. The effects of thermal stress due to overexposure to heat and humidity have been evaluated academically. Outside the academia, the textile worker keeps working in the hot and humid environment, day after day, eight hours a day. And, for eight hours a day, his ears are pounded by the noise of the looms and other machinery endangering his very hearing ability.

It is unfortunate that while health hazards associated with radiation or the supersonic flight of the Concorde make headline news, the fate of millions of workers in established industries is sealed under the imprecise label of " acceptability levels ". The acceptability levels are nothing but a compromise on safety regulations.

In the following pages, SCIENCE TODAY probes into the health hazards faced by the textile mill workers. The probe is not in the nature of an indictment. It is rather an exposition of how much is taken for granted due to ignorance, callousness and inadequate development of technology.

Nana Shivalkar



BYSSINOSIS

HARWANT SINGH

BYSSINOSIS is a disabling lung disease caused by inhaling cotton, flax or hemp dust for several years, though the exact chemical cause remains unidentified. The known facts about the disease are:

● The disease is caused by cotton contaminated with leaves, stems, dust, bracts, and other foreign matter. These contaminants rather than the cotton fibre cause the disease.

● Cotton crop which is machine-harvested is more harmful than the hand-picked ones because it contains more contaminants or trash.

● Workers in the dustier departments of the textile mills such as the bale opening room, the card room, the blow room, and the winding and the spinning rooms show a higher incidence of this disease.

● Workers with already affected lungs or those who smoke are more susceptible to this disease.

Clinically, four stages characteristic of this disease have been noted:

Grade half : Occasional chest tightness on Mondays (or th day of the work week).

Grade 1 *:* Consistent chest ness and/or breathlessnes Mondays.

Grade 2*:* Chest tightness a breathlessness on Mondays other days.

Grade 3*:* Breathlessness on al because of reduced breathing city leading to permanen capacity.

Byssinosis in the later, disa stage (Grade 3) is difficul differentiate from chronic occupational lung diseases. How diagnosis depends on history of exposure to cotton dust, together symptoms and signs of chronic b chitis and emphysema (a pulmo disorder in which the air space the lung are destroyed). Symp are shortness of breath, cough phlegm, irritation of the eyes and plus a fever. The disease is know ' Monday fever ' as the attack oc when the worker returns to work the weekend. Surprisingly, during rest of the week, he may appear t accustomed to the dust and better.

Diagnosis of grades half thro two depends to a large extent on victim's subjective feelings. X- of the chest show no typical tinguishing characteristics. Lung f tion tests by spirometry may, howe show a loss in Forced Expira Volume (FEV). However, no sin simple test has yet been discovere detect the disease in its early sta Only careful interpretation of med history and spirometry results give fairly reliable indications of l grade byssinosis.

Research studies in this coun have shown that the incidence byssinosis varies from 7 to 35 per c By and large, one in five cot operatives probably has the disease some stage of development.

Once an individ reaches Grade 3, he gets into irreversible stage with weakened lu functions. Grade 1 is considered to a reversible condition and the work can be restored to normal health removing them from exposure. Ev at Grade 2, recovery can occur, least to the extent of making t individual fit for some jobs, if further exposure to cotton dust occu Also, not all cases in Grades h through 2 get into Grade 3, ev after years of further exposure. is also not inevitable that all the exposed to cotton dust will g byssinosis. The rate at which t

The susceptible worker . . .

isease progresses depends upon the mount of dust inhaled and on the isceptibility of the individual.

We have said the illness is not eadily distinguishable from other ng diseases when it reaches the reversible stage of Grade 3. Hence, is very difficult to marshal indisput-ble or legally acceptable evidence to rove that this condition was caused y cotton dust alone and not due to ronic bronchitis or emphysema hich has naturally occurred or by ears of heavy smoking or years of ving in the polluted atmosphere of a ty. It has been observed that in areas here cotton dust concentration is less an 1 mg/m³ (milligram per cubic etre of air), byssinosis is more or ss absent. Hence the TLV (threshold mit value) for workers exposed to otton dust has been fixed at 1 mg/m³.

Curiously, acute respiratory illness om low-grade, contaminated cotton a disease distinct from byssinosis. s symptoms usually begin within the rst six hours of exposure. There is tigue and generalised aching, norexia (loss of appetite), headache, ausea followed by vomiting and a mperature of about 102°F (39°C). ome patients may complain of bdominal pain and retrosternal (be-ind the sternum or breast bone) dis-omfort on taking deep breath. These mptoms last for 2 to 5 days.

It would seem natural to suppose hat workers in dusty areas should wear protective respirators or masks. But interviews with the workers have shown their intense dislike for masks. In the first place, a mask over the face can hardly be flattering to one's "looks"! Further, if a mask is tight-fitting there is a risk of getting dermatitis along the area of contact. Also, if the filters (in the masks) are not cleaned or changed frequently, they get choked, increasing the breathing resistance.

. . . and the ubiquitous cotton dust

For the protection of the mill workers from byssinosis, a programme of medical screening and surveillance is very important. This health monitoring programme would identify clearly the susceptible people (such as asthmatics) during pre-employment medical examination. The periodic medical examination should include FEV (Forced Expiratory Volume) and this should be done every six months. Workers beginning to show symptoms of byssinosis should be removed from exposure before the disease advances.

Dr. Harwant Singh (54), Deputy Director (Medical) of the Central Labour Institute at Bombay, where he also heads the Industrial Medicine Division, has been actively engaged in the field of occupational health problems in industries for the past 23 years. He was Medical Inspector of Factories and Certifying Surgeon in Punjab for 10 years before joining the CLI. He is currently working on multidisciplinary occupational health investigations in 19 categories of priority industries/processes.

Recommends reading : **1.** J. A Merchant *et al.* 1975. Responses to cotton dust. *Archives of Environmental Health*, 30 : 222–229. **2.** M. Khogali. 1976. Byssinosis: a follow-up study of cotton ginnery workers in the Sudan. *British Journal of Industrial Medicine*, 33: 166–174. **3.** R. Rylander and M. C. Snella. 1976 Acute inhalation toxicity of cotton plant dusts. *British Journal of Industrial Medicine*, 33: 175 180. **4.** E. Clonfero, *et al.* 1976. Acute and chronic effects of cotton dust inhalation: a study on byssinosis. *Medical Lavoro*, 67: 427 442

Dust and protein concentrations—a study

Presenting a paper on the quality of air in some textile mills with special reference to byssinosis, Pandit and others (*Proceedings of the Second National Conference on Safety*, National Safety Council, Bombay, 1971, p. 277) referred to other studies carried out in India involving one mill in Delhi and 13 in Ahmedabad, where the incidence of byssinosis ranged from 6·3 to 8·4 per cent. A medical student had found that the incidence in some mills in Nagpur was 13·5 per cent. Pandit and co-workers selected four mills processing coarse cotton (coarse mills D, E, F and G), three mills processing fine cotton (fine mills H, I and J) and three ginning presses (A, B and C) for studying the quality of the air. They determined the dust concentration as well as the protein content in the various departments (mixing, blow room, fly frame, carding, spinning, weaving and willows room). The average dust and protein concentrations in the various mills and ginning presses are given in Table 1.

TABLE 1

Mill/Ginning press	Average dust concentration, mg/100m³	Average protein concentration, mg/100m³
Fine Mill J	140	4·96
Fine Mill I	178	4·83
Fine Mill H	211	5·37
Average for J, I & H	176	5·05
Coarse Mill G	197	8·19
Coarse Mill F	236	14·10
Coarse Mill E	326	6·52
Coarse Mill D	336	11·74
Average for D, E, F & G	273	10·13
Ginning Press C	247	11·20
Ginning Press B	553	14·80
Ginning Press A	1,489	23·80
Average for A, B & C	763	16·60

It is seen that all the mills studied had dust concentrations above 100 mg/100m³. The results indicate that if byssinosis is related to dust concentrations, then the incidence of the disease in the ginning presses is maximum, followed by coarse mills and fine mills. Though there is no general correlation between the dust concentration and the protein content, high values of protein may explain the higher incidence of byssinosis.

V. A. SHENAI

THE SCOURGE OF THE COTTON DUST

V. A. SHENAI

COTTON dust contains many substances including polysaccharides, lignin, lipids, proteins, pigments, terpenoids, coumarins, flavenoids and tannins. Many investigators have expressed concern over the presence of these organic substances in cotton dust that are hazardous but ignored on the ground of their negligible quantity.

R. F. Foreness and R. D. Gilbert of North Carolina State University and P. Sasser of Cotton Inc. of North Carolina, USA, (*Textile Research Journal*, October 1976, p. 738) have found that cotton dust, trash and bracts have high inorganic contents and that a significant amount of them is water soluble. They also contain ash of seven to 43 per cent. Elements like nitrogen, chlorine, phosphorus, potassium, calcium, magnesium, manganese, copper, zinc, sulphur, and oxygen and also potassium chloride and potassium sulphate have been identified in the ash. The scientists feel greater attention should be paid to the inorganic content of cotton dust in the etiology of byssinosis.

It has also been shown that airborne cotton dust collected on an electrostatic precipitator in a card room processing cotton contains 10 earth minerals and a number of materials of industrial origin like rust particles, paint flakes, calcite, steel, brass and aggregates derived from furnace products.

Another study conducted by A. C. Griffin of Cotton Ginning Laboratory, and J. B. Hatcher of Clemson University and J. B. Cocke of Cotton Quality Research Station, USA, (*Tex. Res. Jou.*, February 1977, p. 129) revealed that the extreme mechanical cleaning of cotton at gins may not provide much relief from byssinotic symptoms among cotton mill workers.

A revealing Indian study on byssinosis in textile mills was conducted by a team of medical research workers from the KEM Hospital, the MGM Hospital and the Central Labour Institute, all in Bombay. The study, conducted over five years during 1970-75, found that the overall incidence of byssinosis in the exposed group was 12 per cent on the whole. The study group had selected three cotton mills:

Mill A — machinery installed in 1921 and modified in 1952 and 1965-67.

Mill B — machinery installed in 1930-34 and largely unaltered since then.

ll C — new and wholly air-conditioned.

The number of dust-exposed work- examined was, 432 from mill A, 1 from mill B and 156 from mill C; number of control workers: 177, 5 and 50, respectively.

The incidence of byssinosis in the lls, A, B and C was 16, 8 and 3 r cent, respectively, in the exposed oup, and 2, 3 and 0 per cent in the con- l group. Thus, mill A despite some odernisation had a higher incidence. ie incidence was higher in the card- g section (14 per cent) as compared the spinning and winding sections 0–11 per cent). Mill B had shown a wer incidence in the spinning section per cent as compared to 19 per cent Mill A), probably due to oiling of tton practised in the mill. Mill C, o, showed a similar 3 per cent in- dence in the spinning section, though re the reason for the lower figure uld be attributable to the shorter rvice put in by workers and the fact at the mill was relatively modern.

TABLE 2. MEDIAN DUST LEVELS MEASURED OVER FIVE YEARS 1970-75)'

Section	Median dust level (mg/100m³)		
	Mill A	Mill B	Mill C
1. Blow room	785	762	115
2. Scutching	145	156	116
3. Carding	334	456	300
4. Drawing	180	238	215
5. Combing	177	59	131
6. Interframe	380	241	74
7. Spinning	122	133	Traces
8. Winding	325	167	—
9. Weaving	378	144	—
10. Folding	53	109	—
Average	288	247	136

[From a survey conducted by medical researchers from the KEM Hospital, the MGM Hospital and the Central Labour Institute, all in Bombay, sponsored by the Indian Council of Medical Research, Delhi, and the Bombay Millowners' Association.]

Cotton—from boll to bale to bobbin

White fleecy cotton fibres, obtained from the ripe, burst cotton bolls, are picked up before discolouration takes place due to sunlight and air.

In hand-harvesting, a principal advantage is the careful removal of cotton locks from the burs, though the job is laborious. On the other hand, machine-harvesting (pulling) brings open bolls and burs together with leafy material. Hence "picked" cotton is purer than "pulled" cotton.

The process of separating fibres and seeds is known as ginning. Here agitated seed cotton comes into contact with a number of circular saws. The sawteeth cut the fibres without harming the seed. The separated cotton is compressed and made into bales.

Workers in the blow room, where the opening and cleaning of cotton bales are carried out, are severely exposed to the cotton dust. Here the cotton is subjected to vigorous beating several times. Solid impurities are separated. Low-grade cotton is subjected to additional beating. Then the cotton passes through a series of calender rollers and is finally made into a lap or web.

The lap is then fed to a scutcher. This is a major cleaning unit where opening and cleaning of cotton is continued with vigorous beating.

At this stage, the fibres are still in a tangled condition and contain waste material. Before this raw stock can be made into yarn, the impurities must be removed and the fibres must be straightened. The process of arranging the fibres in a parallel fashion (sliver) is known as carding. The lap is unrolled and drawn on a carding machine. Dust, leaves, twigs and other foreign matter are removed here. In the process, a large number of very small fibres constituting the cotton dust is let into the card room.

Where the fibre is intended for fine yarns, the sliver is put through an additional straightening process called combing. In this operation, fine-toothed combs continue straightening the fibres until they are arranged with such a high degree of parallelism that the short fibres are combed out and separated from the longer fibres. Here almost one-fourth of the raw cotton is shed as waste.

In the drawing-out process, several slivers are combined to remove any variation in the single slivers. After several stages of drawing out, the condensed sliver is taken to the slubber, where rollers similar to those in the drawing frame draw out the cotton further. Here the slubbing is passed to the spindles, where it is given its first twist and is then wound on bobbins.

These bobbins are placed on the roving frame, where further drawing out and twisting take place until the cotton stock is about the diameter of a pencil lead. The roving on bobbins is placed in the spinning frame, where it passes through several rollers running at successively higher rates of speed until it is a drawn-out yarn of a desired size.

The median dust levels in different sections of three textile mills were determined by the filter paper precipitation method and the readings are given in Table 1.

S. K.

To a large extent, the incidence of byssinosis depends on the duration of service. Thus, it was seen in 7 per cent of those working for up to 5 years and in 18 per cent of those with the longest service (more than 25 years).

The KEM–MGM–CLI study did produce a few other pointers. For instance, coarser the cotton in use, greater are the dust levels. Air-conditioning in the spinning department reduces dust greatly. New single process blow rooms have much less dust than the old multiphase variety. However, air-conditioning did not reduce dust much in the card rooms. Another significant finding of the study was that in dusty areas, the drop in lung function was reversed by drugs like orelprenaline and salbutamol, which are available in India through doctors. Orelprenaline or salbutamol aerosol reverses the natural fall in lung function over four hours, but has no

sustained cumulative effect. But oral salbutamol with a combination of ephecrine (25 mg) and theophylline (180 mg) gave a slightly better result in regard to improvement in lung function, which on regular administration was sustained for over 12 weeks. There were only minor side-effects like tremors, giddiness, headache and weakness. In their opinion, diet does not seem to affect the incidence of byssinosis except in a general way, that is, high protein content in the diet may help build better resistance in the workers.

Regarding the precautions to be taken in the working atmosphere, the study team recommended certain measures to reduce dust, like replacement of multiphase blow rooms by single phase machines, enclosures with overhead hood exhaust on carding machines, air-conditioning in the spinning area and better exhaust ventilation in the winding area.

Some cotton dust control measures have also been suggested by Mr. R. G. Kulkarni, director of a textile machinery manufacturing firm in Bombay. For example, a rotary filter can be fitted to a blow room line or can be used as a central dust collection unit for a group of carding machines. This essentially consists of a primary filter comprising a perforated drum rotating at a speed of 1–3 rpm on wh the dust from the blow room line group of carding machines is depos after being drawn through exha ducting by a powerful fan. The du then delivered in the form of a or sheet into a trolley. The exhaust passes through a filter bag arran ment, known as a secondary fil and clean, filtered, respirable air then be circulated to the departm or discharged into the atmosphe Alternatively, a dust collection u for carding machine is available as individual unit for each card with filter box, plenums and individ drive. Suction is applied at the poi at which dust originates.

Dust collection units, it appea have been installed in a number textile mills now. But how far w such devices go to battle the scour of the cotton dust? For one, hundre of textile mills exist which are eith reluctant or unable to invest in pr tective equipment. And air-conditio ing is so enormously expensive th except for a handful of giants in t industry, others can only contempla the idea academically. (There are ov 700 cotton textile mills in India em ploying 8,18,000 shift workers!) F another, the health hazards posed cotton dust can be minimised throu regular and vigilant clinical screeni of all exposed workers. How ma textile mills are willing or equipped undertake this? And, finally, there the all-pervasive ignorance among the workers as well as their fatalist acceptance of all physical discomfor as long as they are able to stand ere and punch their job cards.

THE HORROR OF HEAT AND HUMIDITY

AMONG the less known factors affecting an industrial worker's health is thermal stress — the physiological effects of high temperature and humidity. With sustained temperature beyond 100°F (37·7°C) and relative humidity of 80-90 per cent, a worker may experience heat stroke, vomiting, giddiness, nausea and may also become unconscious. There is a rapid increase in the rate of heartbeats and often a severe headache grips the worker. Abnormal thermal stress reduces the appetite and, consequently, most of the workers lose weight within a few years.

The effects of thermal stress have been studied in some detail by researchers. While these can tabulated, few seem to remember th the thermal stress in industries in tropical country like India is f greater than that prevailing in th West.

In textile mills, rather hig humidity is required and the increas has to be artificially induced at time In the process, there is a risk of oxyge depletion in the atmosphere. Also high humidity means the sweat on th human body cannot evaporate and th metabolic heat accumulates uncon sumed. Thus, there is a heat build-u in the body both from within an without.

Way back in 1955-56, J. S. Haldan had first established the upper limi of human tolerance to heat. He ha pointed out the wet-bulb temperatur and the velocity of air movement a the cardinal factors affecting th thermal stress. The safe upper limi

linical effects of thermal tress

If the exposure to heat is prolonged eyond a critical period, the body echanism crumbles. Any ill-effect of eat is generally known as 'heat roke'. Heat stroke occurs suddenly hen body temperature rises above critical level (about 105°F or)·5°C), and is accompanied by loss consciousness or convulsions and omplete cessation of sweating with ot and dry skin. When the body mperature remains below 105°F 40·5°C) and there is no loss of onsciousness, it is termed as heat yperpyrexia.

While heat stroke is the most serious f disorders, there are a few more ategories of clinical classification. hese are: heat exhaustion, heat yncope and heat cramps. Heat exhaus- on can be attributed to two factors: hortage of water in the body and salt eficiency. In the case of water shortage, he symptoms are headache, extreme hirst and dryness of mouth. There is hild fever, with body temperature sing to 102°F (39°C) and very little rine.

Heat syncope is the commonest ill ffect of heat. In its milder form, blood ressure falls and the person collapses uddenly. There is practically no rise in ody temperature. This condition results om pooling of blood in the lower limbs ue to enlargement of blood vessels, vith the result that the amount of lood returning to the heart is reduced, vhich in turn is responsible for lowering f blood pressure and lack of blood upply to the brain.

Occasionally, the heat-stricken person xperiences severe pain in the calf and high muscles, which lasts a couple of minutes. This is called heat cramp and s usually experienced after a prolonged xertion in severe heat.

S. K.

tolerable temperature thus estab- hed is 85°F (29·5°C) effective mperature, where effective tempera- re is a composite index of tempera- re, humidity and rate of air ovement. This value is maintainable ith air velocity at 30 metres per inute. Actually, the tolerance of eat by any individual depends on diation, air velocity, nature of cloth- g worn, rate of energy spent, age, atus of health and the rate of sweat- g.

The thermal stress prevalent in dustries like iron and steel and ement is many times higher than in textile mill. This does not mean that ermal stress in a textile mill is significant in terms of hazard. As ng as it is above the tolerance level human beings — which it is in textile mill — the question of health azard will continue to raise its ugly ead.

Let us identify the sources of heat in a textile mill. A prominent one is steam, used extensively in many departments. Apart from the actual steam formation, steam pipes radiate a lot of heat. The calendering machine consists of steam-heated hollow drums. In bleaching, boiling, finishing, curing, dyeing and drying processes, high temperature steam is used. The cloth singeing process involves burning of open gas flames. Heavy machines in constant motion also contribute to the existing atmospheric heat.

Both cotton and synthetic fibre processing mills require steam for bleaching, finishing, dyeing, etc. However, since synthetic fibres do not require humid atmosphere in spinning, steam is used as a humidifier in cotton textile mills only. Added to this is the metabolic heat generated by the workers' bodies. This heat is dissipated to the environment. Should there be heavy enclosures and fewer ventilators, the agony of abnormal heat is increased.

Between the upper limit of tolerable heat and the upper level of comfortable warmth, there is a zone of temperatures in which some physiological evidences of ill-effects have been reported. The harm done is indirect and manifests itself in high accident rates, increased sickness among workers and lowered productivity.

Accident rates were reported to be minimum in the range of 65°F (18·3°C) to 69°F (20·5°C); at 75°F (23·9°C), the rate had increased considerably. As far as sickness goes, men at work in the hot environment of textile mills were reported to suffer from rheumatism of increased severity, respiratory diseases and heat-induced cramps. Compared with men working under cooler atmospheric conditions, their sickness rates were higher by 20 per cent. It has also been noted that seasonal changes in temperature do affect the rate of production and that the output in hot weather is distinctly lower than that in cool weather. For example, in textile mills, above the wet-bulb temperature of 84·3°F (29°C) a significant drop in production has been recorded. The upper limit of comfort zone is slightly below an effective temperature of 86°F (30°C). The tendency to seek rest among workers increases above an effective temperature of 85·2°F (29·5°C).

If the temperature exceeds 86°F (30°C), there is a likelihood of salt exhaustion but this does not usually occur in an Indian worker due to his higher dietary intake of salt.

In Maharashtra, during the past 16 years textile mill workers in at least four mills were affected by thermal stress en masse. Though India is a tropical country,

An air-conditioned textile mill . . . how many in India are willing to instal or able to afford air-conditioning?

its inhabitants are not blessed with automatic acclimatisation for work in artificial climates that are very hot. Even those acclimatised to work in hot environments may not endure it permanently. Living for a few days or a few weeks in cool conditions results in loss of this acclimatisation.

It is very important that employers direct new entrants, or those who return after long absence, to jobs involving severe thermal stress to adjust themselves slowly and carefully to the new environment. The workers must also be informed that profuse sweating is harmless and that large amounts of water and ample quantities of salt must be ingested to avoid the ill-effects of water or salt depletion. Also, cool drinking water is more beneficial than either warm or very cold water. There is a misconception that to drink while sweating is dangerous. It is necessary to replenish the sweat losses by fluid consumption, preferably at the end of each hour.

Central air-conditioning is deemed to be a good solution to the problem of thermal stress and a few mills in India have air-conditioned their premises. But this involves huge costs and medium and small mills cannot afford this. Dehumidifiers will not serve any purpose since the optimum level must be maintained. Even if chemicals like silica gels could be used, various disadvantages preclude any such attempt.

A way out, perhaps, would be well circulated air. Air movement promotes faster evaporation of sweat from the body. Brisk breeze which displaces the stagnant air can ease the situation of intolerable heat. At least, 20 to 25 air exchangers are necessary to help maintain an effective temperature of 85°F (29°C). However, at temperatures above 100°F (37·7°C), high velocity air may prove to be counter-productive as it can add large amount of heat to the human body.

If excessive heat is inescapable, a slowing down of the rate of work or increased periodicity of rest will help to keep the combined physical and thermal stresses within safe limits. Also, the less the amount of clothing worn, the more the workers' ability to withstand thermal stress except, of course, under conditions which call for a clothing shield.

There is also the point of pre-existing aggravators. Inadequate rest and loss of sleep or " alcoholic hangover" reduce the ability to work under stress of excessive heat. Other diseases in a worker may also have similar inhibitory effect. Wherever the source of heat is located near the workers, radiation shields can be placed between the hot machine surfaces and the workers. Sufficiently cool air may be supplied to the machine and the resultant hot air may be exhausted separately. Where heat load is moderate or separate ventilation of machines is not possible, cooled air can be circulated through the room itself.

On the outside, the overall heat load can be kept to a minimum by several methods. These include shading of roofs, walls, windows, etc by the use of false roofs, louvers, wide overhanging roofs, shade trees, creepers on walls, venetian blinds, reflective paint on roof, spray cooling of roof and walls, and installation of insulated ceilings with ventilation between roof and ceiling.

Although there are factory regulations to check the artificial humidification in the textile mills, no legal action can be taken if the workers are exposed to high temperature or humidity in a mill. The installed hygrometer is meant to be only a cautionary device.

The best that can be done to protect the workers, though not completely, is to give them frequent rest periods in a spacious, airy and comfortable place. Periodic medical check-up should be provided. And such not-so-costly steps as increased ventilation and air-exchangers can help mitigate the problem to some extent.

S. KUMAR

Some minor occupational diseases encountered in the textile industry

ATHLETE'S FOOT is a dermatophyte infection of feet found in the bleaching departments, as a result of continuous contact with wet floors. The infection is transmitted to the webs of the toes and can get severe if the toes are not kept clean and dry.

EYE STRAIN is commonly found in the drawing-in department. The operation of drawing-in is a skilled job wherein the design of cloth is determined by adjusting every thread individually on a beam. Consequently, in the course of years, they develop asthenopic symptoms. (Asthenopia is weakness of the eye muscles or of visual acuity, sometimes accompanied by pain and headache.) Periodic eye check-up is required for the early detection of cases. It is equally important t adequate illumination is provided prevent eye strain.

SHUTTLE KISSING: The weft cop bobbin of a non-automatic loom shut has to be replenished every 4 to minutes and this is done by placing t lips against the shuttle eye and sucki up the thread. The operation of " shut kissing " is done a few hundred times day by each weaver. This practice unhygienic because fibre dust from t wet yarn is drawn into the mouth. Als in shift work, three different weave use the same shuttle in the course of day, thus increasing the risk of cros infection.

HARWANT SING

CHEMICA HAZARDS IN TEXTILE MILLS

V. A. SHENAI

ABOUT 15,000 chemical co pounds are widely used industry, agriculture commerce. Yet only a have been thoroughly investigated to their adverse effects on hum health. And, of these, some do within the realm of the tex industry.

In the textile industry, vari chemicals are used for carrying various processes like bleaching, d ing, printing and finishing. It is n established that many of these che cals contaminate the air, specially the immediate vicinity of the ope tional zone. It is inevitable t workers in these operational zo will be affected. For example, inha

tion of sulphur dioxide, sulphur trioxide, carbon disulphide, etc has been shown to increase the incidence of coronary diseases; it also brings about changes in blood chemistry and reduces the brain's ability to exert control over muscle movement. Excessive exposures can lead to fatalities.

Then there is the risk of skin damage, particularly in the finishing department. Direct contact with acids, alkalies, oxidising agents, reducing agents, detergents, solvents and resin precondensates can cause immediate damage in the form of burns or can produce long-term complaints like dermatitis, eczema and other skin diseases. The eyes, the mucous membranes of the nose, the fingers and the hands are highly susceptible.

In the recent decades, with the diversification of technology, making of dyestuff has become an industry by itself. Most of the mills do not prepare dyes but buy them. In other words, the hazards posed by the chemicals used in making dyes have shifted from one industry to another.

But this in no way makes the textile industry any safer. Innumerable other chemicals are being used in textile mills and a comprehensive or conclusive list of them is not possible. However, some of the most commonly used chemicals can be identified and their effects studied. This has already been done.

Nana Shivalkar

CHLORINE: Many cotton mills in India use sodium hypochlorite as the bleaching agent on a large scale. In some cases, the chemical is manufactured by the mills themselves. Here chlorine gas is bubbled into caustic soda solution; however, in the process the entire amount of chlorine is not absorbed. The residue, besides the wastage, becomes a health hazard.

The human body is highly sensitive to chlorine. Exposure to 10-20 mg/m concentration of chlorine can cause stinging or burning sensation in the eyes, nose and throat and sometimes headache. Redness and watering of eyes, sneezing, cough and loss of voice often occur. There may be bleeding of the nose, too. Exposure to 40-60 mg/m³ concentrations for more than 30 minutes is dangerous and concentrations of more than

290 mg/m³ cannot be tolerated for more than one minute.

FORMALDEHYDE: It is a gas available as approximately 40 per cent solution in water, as formalin. It is used in the making of urea-formaldehyde precondensate for resin finishing of cotton or rayon fabrics. Since the fabric treated with this chemical is heated to high temperature, there is a considerable release of fumes.

Formaldehyde has a characteristic odour by which it can be detected even at concentrations well below one part per million (ppm) in the air. At four to five ppm, the discomfort — tingling sensation in the eyes, nose and posterior pharynx — increases rapidly. Concentrations of 10 ppm can be tolerated with difficulty for only a few minutes. Profuse lachrymation (watering of the eyes) occurs in all people. At 10 to 20 ppm concentrations, normal breathing becomes difficult. Nasal and respiratory irritation may persist for an hour after the exposure. Exposures for five to 10 minutes to levels of 50 to 100 ppm might cause serious injury. Clinical data on 25 people engaged in the manufacture of urea-formaldehyde resins with exposure periods ranging from five to 18 years at below 10 ppm level show dermatitis in four of them. In another study, a worker was found to develop sudden eczematous reaction on the face, the neck, the eyelids, etc a few days after starting work.

CRESOLS OR CRESYLIC ACID: In mercerising, it is used as a wetting agent. Fatalities can occur from prolonged and/or extensive contact with these compounds. Because of their low vapour pressure and disagreeable odour cresols do not present any acute inhalation hazard. They can easily be detected and inhalation avoided. Acute exposure by all routes of absorption may cause muscular weakness, gastroenteric disturbances, severe depression, collapse and even death. Injury to the lungs, liver, kidneys, pancreas and spleen may also occur.

PENTACHLOROPHENOL: Carbohydrates like starches and gums are widely used in the textile industry both before weaving, and after — in printing and finishing. The carbohydrates are food for micro-organisms which chemically degrade them; they lose their adhesive and thickening properties. To prevent the growth of the micro-organisms, the fabrics are treated with pentachlorophenol.

After prolonged or repeated contact with the skin, the dust or solutions of pentachlorophenol can cause dermatitis and systemic intoxication. Low concentrations (3 mg/m³) cause irritation of the mucous membranes of the nose, the throat and the eyes. Solutions as dilute as one per cent may cause irritation if contact is prolonged or repeated frequently. Skin contact or inhalation of the dust should be avoided.

DICHLOROBENZENE: This liquid is immiscible with water but can be emulsified in it with the help of an emulsifying agent (another chemical). This emulsion is used in the dyeing of polyester fibre materials which are supposed to be dyed in closed machines so that the dyeing materials do not pollute the surroundings. However, in practice, much of the cloth is dyed in open dyeing machines, where closed ones are not available.

Dichlorobenzene primarily injures the liver and the kidneys. Short exposure at high concentrations may result in depression of the central nervous system. Exposures up to 44 ppm are considered safe, as no injury under these conditions has been reported. At 50 ppm, the chemical's odour can be detected, and at 100 ppm, irritation is felt.

CAUSTIC SODA: This is a very common chemical used in large quantities, especially in cotton textile mills — in bleaching, mercerising, dyeing, etc. It is bought in bulk. As the drum is broken open and l blocks of caustic soda are cut out a dumped in water, the water nea boils and spurts. Small chips of caus soda often fly and may land on t head and other parts of the body people standing nearby.

Direct contact with caustic so causes characteristic irritation of nas tissues and sneezing. There is usual a rapid destruction of any tissue th comes in contact with the solutio Eyes are susceptible to damage.

SULPHURIC ACID AND HYDRO CHLORIC ACID: Both these aci are extensively used in dyeing pro cesses and the emission of the vapours and mists pose considerabl health hazards. Also, their highly corro sive nature makes them dangerous t handle. Skin burns occur even if single drop falls on the skin.

Care must be taken while dilutin the acids and alkalis. Eyes must b protected with goggles. Splashing o liquid and solid materials is to b avoided. The operational area mus be well ventilated. And the chemical should be stored separately and clos to the work area so that they don' have to be transported far. Wate must be available in plenty to enabl washing.

The foregoing discussions cove only a few of the many hazardous chemicals used in the textile industry. Though there are enough safety rules regarding the storage and handling methods of such items and specific protective measures have also been suggested, carelessness often costs many lives.

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THE NOISE NUISANCE

S. PURUSHOTHAMA

THE harmful effects of noise on human health and well-being have been documented extensively and these include increased annoyance, mental tension, irritability and emotional disturbances at work and at home. The physiological effects can vary from constriction of peripheral blood vessels to dilation of pupils, muscular tension, increased diastolic pressure and glandular stimulation. Data from industrial workers suggest greater circulatory, heart and equilibrium problems in workers exposed to very noisy environments.

The most pervasive and dangerous harm from high noise level is the permanent incurable deafness which results due to prolonged exposure to noise levels above 85–90 dBA. In most of the textile mills, the noise levels are above the threshold of danger and have proven potential to cause permanent hearing loss. The workers in the spinning and weaving departments, whose number exceeds 8,00,000, are the worst affected. The noise level in a large weaving shed is in the range of 100–105 dBA and those in the spinning and preparatory departments, between 85–95 dBA. It would be impossible to carry on any spoken communication at these noise levels.

The noise hazard in textile mills in foreign countries is equally severe. But the difference lies in our managements' supreme indifference to the problem, whereas their counterparts elsewhere do take all possible steps to prevent damages due to this hazard. In the USA, at least, the Occupational Safety and Health Act stipulates the noise level in textile mills to be maintained below the threshold limit value (TLV). The regulations under this act in the USA and statutory provisions in other countries permit only two hours' daily exposure at 100 dBA and there is a move to reduce this further. New machines are manufactured bearing this in mind. If at all old machinery has to be used, the workers must be well protected against the hazard. If any worker is affected, the compensation to be paid to him is so prohibitive that the employer would prefer replacement of the machine to paying compensation. Also, the stringent laws act as the motivating force to develop new methods and devices to combat the problem.

Factories are obliged to display "Caution" signs wherever exposure to noise is hazardous and this helps to keep the workmen aware of the potential hazard they are exposed to.

The Indian Factories Act does not specify any measures to protect workmen against high noise levels. Even the extent of damage caused to an already impoverished Indian work force due to high noise levels has not been assessed. Everyone including the government, the trade unions and the managements seems to have turned a deaf ear to the question of protection against noise.

The initiative for taking control measures has to come, of course, from the industry. In the final analysis,

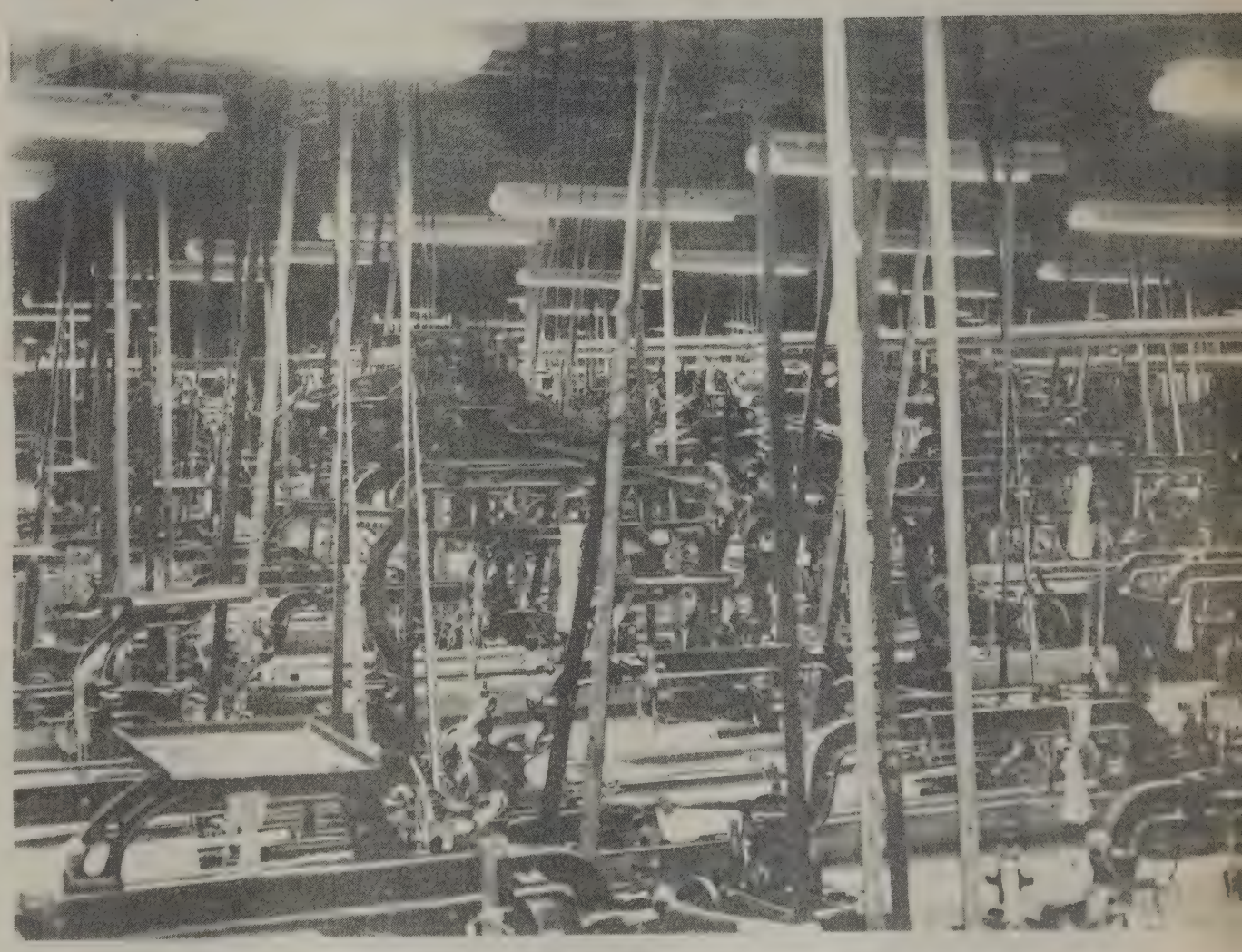
The TLVs

The threshold limit values (TLV) refer to sound pressure levels that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech.

The commonly used criteria are the TLVs recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), shown below:

Duration per day (hours)	Sound level (dBA)
16	80
8	85
4	90
2	95
1	100
1/2	105
1/4	110
1/8	115*

* Ceiling value beyond which exposure is risky.



The ceaseless looms . . . a perpetual source of noise

TABLE 3: TYPICAL TEXTILE MACHINERY NOISE LEVELS

Equipment	Noise levels in dBA
1. Opening and Blow Room Machinery	85– 94
2. Card Room Machinery	87– 90
3. Draw frames & Spinning frames	89– 96
4. Winding Machines	85– 89
5. Warping Machines	85– 87
6. Sizing Machines	80
7. Large Weaving Shed	100–105
8. Shuttleless Weaving	90– 96
9. Shearing & Cropping Machines	75– 85
10. Folding Department	69– 75

the most economical way of noise reduction is to design less noisy machines. Since much of our textile machinery is built indigenously, organised R & D efforts are required to develop quieter machines. Components like gears and other mechanisms should be redesigned to reduce noise.

In many other countries and in a few mills in India, shuttleless looms are employed. While these are faster in operation, they are less noisy compared to the conventional looms (90–95 dBA in a large shed). The noise can be reduced to less than 90 dBA in such sheds by using proper machine foundations and by "soaking" the noise through suitable absorbing materials. The workmen should also be supplied with ear defenders and educated to use them properly.

Audiometers and audiometric test booths for examination of the workers are available locally. The mill doctors should be encouraged to examine the workers to detect early cases of hearing damage and, if necessary, help in their rehabilitation. With the reported move to include 'noise-induced hearing loss' as a compensable disease, it is hoped that increased interest will be taken by mill managements to reduce the noise hazard.

S. Purushothama (34), Assistant Director (Engineering) of the Central Labour Institute in Bombay, is at present on deputation to the newly-formed Loss Prevention Association of India as Technical Manager. He has conducted several educational, training and consultancy projects in the areas of safety and environmental engineering; he took his Master's degree in the latter subject from the University of Cincinnati, USA. He has been associated with a number of organisations like ISI in standards setting and other developmental work.

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THE STATE

While research studies and surve have amply confirmed the vario health hazards in textile mills, wh has the Government done about We posed the question to Dr. G. Davay, Medical Inspector of Fa tories, Maharashtra. Here a excerpts from an interview conduct by SCIENCE TODAY:

A team of medical researchers from Bomb has concluded that byssinosis is prevalent amo 12 per cent of the textile mill workers on average. Don't you think this is rather alarming figure?

G. G. DAVAY: I do not think th prevalence of byssinosis among the mi hands is alarming. I have reasons to belie that the published figures may not refle the real character of the problem.

All those with respiratory troubl in a textile mill need not necessarily b the victims of byssinosis. Their standar of nutrition and living environment an habits may have caused the disease, whic may appear like byssinosis.

The signs, symptoms and possibl treatment of byssinosis are only too we known to the medical world. But I a not sure if its identification is carried ou systematically and objectively, as th diagnosis in the early stages is mostl based on complaints from the individua

Which section of workers in a textile mill most vulnerable to byssinosis?

Waste-handlers in textile mills are th most exposed to cotton dust. Also, thos who clean the machinery on holiday

Nana Shivalkar

OINT OF VIEW...

inhale a lot of the dust. They are mostly contract labourers and usually are not covered by any study group. This way, quite a large group of textile workers prone to byssinosis may go undetected. Also, operators in the mixing, the blow room and the carding section are vulnerable to it.

Is there any safe level of dust inhalation?

Cotton dust contains allergic substances and some people are sensitive to it. So it is not how much dust one can inhale that matters but whether a person should be exposed to dust at all. Desensitisation may help such workers and steps are still to be taken in this direction.

What steps are presently taken by your department to check the cotton dust level to which a worker is exposed?

The Medical Inspectorate tests air samples from the textile mills when necessary. Generally, dust particles of size 2 mm and above are sieved off as they may not reach the inner respiratory tracts. Dust particles of size seven microns and less (one micron = $10m^{-6}$) are respirable and hence ought to be avoided. The TLV (threshold limit value) of dust in air is one mg/m^3 by weight.

We advise the mills to keep the exposures as low as is reasonably achievable, economic and social factors being taken into account. Though there is legislation against hazardous dust emission, it is very vague and has loopholes. No statutory TLV for the dust level is specified in the law.

There is an inhibition among workers in using protective masks or in tying a piece of cloth over the nose and the mouth. It is really the responsibility of management to control dust emission by other means.

There have also been frequent references to thermal stress. What can be done about this?

Hygrometers need to be provided and a record of temperature and humidity must be maintained. The record book is open for scrutiny by the factory inspectors. But here again we can only advise the maximum safe limit (85°F or 29·4°C effective temperature).

What about the chemicals used in the textile mills?

Happily, the government is well armed in the matter of chemicals. The safety rules relating to chemicals like corrosive substances, dyes and certain intermediaries act as a watchdog here. Certain sensitising substances like PVC emulsion and phenolics cause serious dermatitis amongst the processing workers. Avoiding direct contact with these substances by mechanisation will prevent the hazards.

Noise is emerging as a potential health hazard. What is your experience in this regard with particular reference to the textile mills?

I have not yet come across any textile millhand with loss of hearing due to over-exposure to noise. I do not mean that noise does not affect hearing. But in the absence of any direct proof to show that a textile worker with normal hearing loses it after a severe exposure to noise, it is against the ethics of science to exaggerate the hazard. It will amount to creating a scare.

We do advise the factories to reduce the noise level as far as possible. But it is difficult to control noise in certain departments with the present technical know-how. My department is not equipped to measure and study the problem as the scientific world has been seized of it only recently.

You have said unhygienic conditions have affected workers' health. Can you elaborate?

Yes. Incidence of tuberculosis is rampant among industrial workers and the textile workers are no exception. Usually the spitting habit of the workers is a villain here.

The atmosphere in a textile mill is humid and warm. The organisms live long there and they float in the air for a longer time. (In open air and sunlight they die instantly.) An irresponsible worker may spit anywhere and in effect spread the TB. This is true of other contagious and communicable diseases also.

What has your department done in this regard?

Rules insist that spittoons must be provided but in reality they are rarely used. Of course, a dirty spittoon may often be an eye-sore. If the general housekeeping is good and the spittoons are neat and clean, the worker may be tempted to utilise the facility.

A fervent educational programme to avoid the menace of irresponsible spitting will arouse the conscience of workers.

Would you say that the health scene in the textile mills is not as bad as is made out to be?

If I say so, it is because I have in mind the false reporting or erroneous diagnosis by some medical men due to faulty premises which distort the image of industrial hygiene today.

Is not a certain amount of pessimism itself a watchdog of safety requirements?

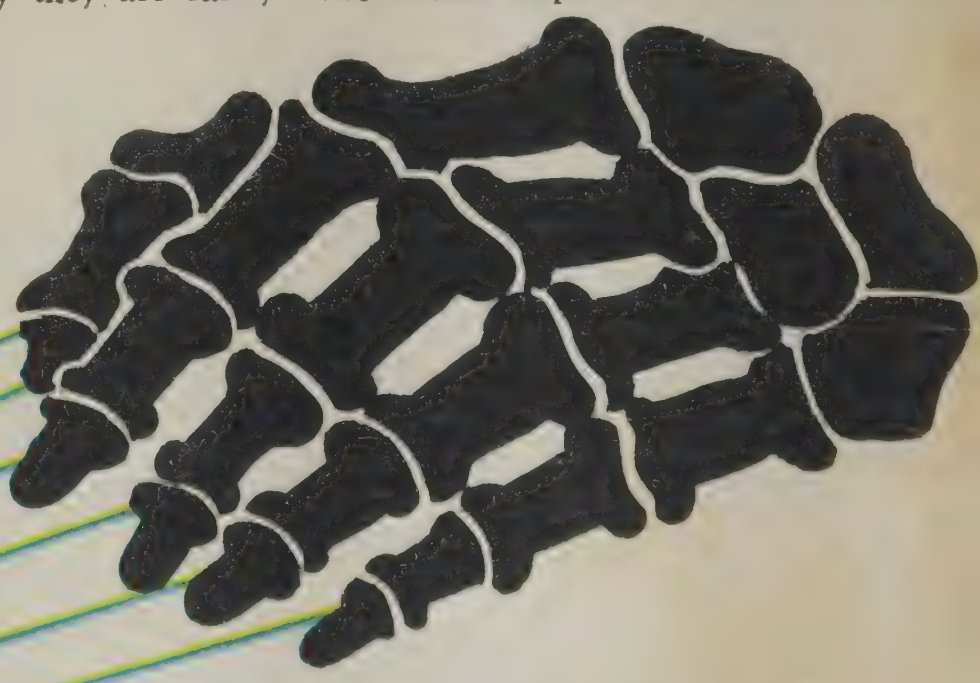
To some extent it is true. But too much of pessimism may demoralise workers in an industry. Hence, an occupational hazard can be highlighted up to an extent where the workers will realise the problem and adopt preventive measures.

Is the Inspectorate of Factories adequately manned to conduct regular, intensive checks at all our textile mills?

The Inspectorate is equipped to inspect the environmental conditions when a need for such a checking arises. Continuous monitoring by the department is not possible. The onus of monitoring the environmental air normally rests with the management of the mills. At least, once a year, an inspector of factories visits the mills. Apart from this, inspections are conducted when accidents are reported or on receipt of complaints.

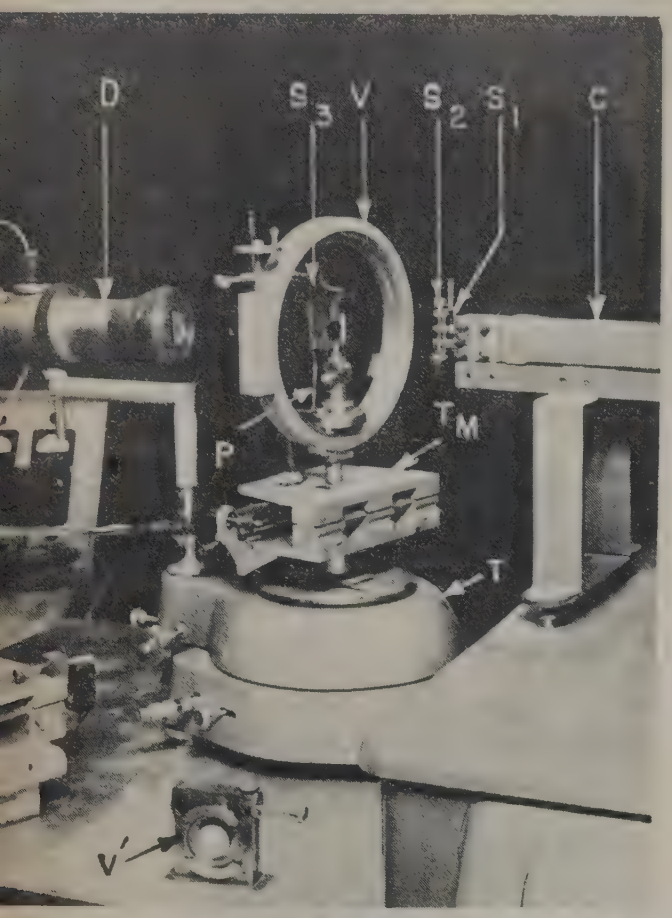
What is the state of affairs in other textile-producing States in India?

Modernising of machinery and techniques has been better organised in Maharashtra compared to Gujarat, West Bengal and Tamil Nadu. However, the overall picture of the industry is the same all over the country. In each state, some mills are well maintained while some are not. Still there are States which lack exclusive medical inspectorates of factories and the fortunate ones have only one or two medical inspectors for the entire State.



[Interviewed by S. Kumar]

Dr. Gourishankar Ganapathram Davay (52) is Medical Inspector of Factories, Maharashtra. Till 1960, he was Medical Officer at the Haffkine Institute, Bombay. His interests include toxicology, occupational health and clinical medicine.



X-ray topography camera developed at the NPL, New Delhi. C is a collimator having two slits S1 and S2. V and V' are two vertical circle goniometers; TM is the traversing mechanism; T is the turntable; S3 is another slit to stop the direct beam; P is the plate holder and D is the X-ray detector

Improved Lang camera

AN improved version of the Lang camera, used to record X-ray topographs of nearly perfect crystals, has been developed by the National Physical Laboratory, New Delhi.

The Lang Camera is used to record topographs of nearly perfect crystals. The technique of X-ray diffraction topography is fairly recent and has assumed great importance due to the ever-growing use of single crystals in sophisticated electronic devices. The single crystals used in these devices should not only have their purity within well specified limits but also have a perfect arrangement of atoms within their bodies. Any deviation from perfection may lead to the failure of a device even if the material has the specified purity. Therefore, the need to characterise single crystals for perfection is great. X-ray diffraction topography is a non-destructive method for this purpose.

In the Lang camera, an X-ray beam from a microfocus X-ray generator is collimated by a special collimator and allowed to fall on the crystal under investigation. The crystal is mounted on a vertical circle goniometer (VCG), which is mounted on a traversing mechanism which in turn is mounted on a turntable. The crystal can be rotated around two mutually perpendicular axes; one of the axes is provided by the VCG and the other is provided by the turntable. The crystal is translated across the X-ray beam by means of the traversing mechanism. By suitable alignment the crystal is made to diffract X-rays from a desired set of lattice planes. The diffracted X-ray beam is recorded on a photographic film/plate which is also rigidly fixed on the traversing mechanism. The diffracted beam contains information about the variation of perfection in the specimen.

The special features of the equipment developed at the NPL include two special vertical circle goniometers and a special "collimating system" with which the divergence of the exploring X-ray beam in the horizontal plane can be reduced to less than 40 seconds of arc.

A crystal has an extremely periodic arrangement of atoms inside its body. Any deviation from this periodic arrangement is called a lattice defect or lattice imperfection. The lattice imperfections can be classified thus:—

Grain boundaries: These are boundaries which separate two regions of a crystal which are highly misoriented with respect to each other. In fact, the two parts of the crystal can be considered as separate crystals.

Low angle boundaries: These are boundaries which separate two adjoining regions of a crystal which are misoriented by a few minutes of arc from each other; such crystals can be considered as one single crystal for all practical purposes.

Dislocations: These are genera called line defects. A dislocation i defect whose one dimension is atomic unit in size, while the ot dimension can be very large. example, an edge dislocation is eit an extra half atomic plane or a missi half atomic plane in a crystal.

Point defects: These are either m sing atoms leading to vacant latt places known as vacancies, or ex atoms in lattice known as interstitia Interstitial atoms can be both ato of the parent material as well foreign or impurity atoms. Sometim point defects aggregate into bigg defects.

All the defects mentioned abo are crucial in influencing t properties of a material. Using X-ra diffraction topography, one can ve easily see grain boundaries, low ang boundaries and dislocations. An X-ra topograph is very similar to an optic photograph taken with an ordina camera. On a photographic negati we recognise different objects by t amount of light reflected or scatter by these into the camera. For exampl the teeth appear dark because mo light is reflected by these. Similarl in a topograph (kinematic type the defects appear black because th diffract more X-rays than the perfe regions of the crystal. This is wh X-ray topography is a direct metho of recording defects. Not only can o say whether the crystal is perfect not, but also how many defects which type are present.

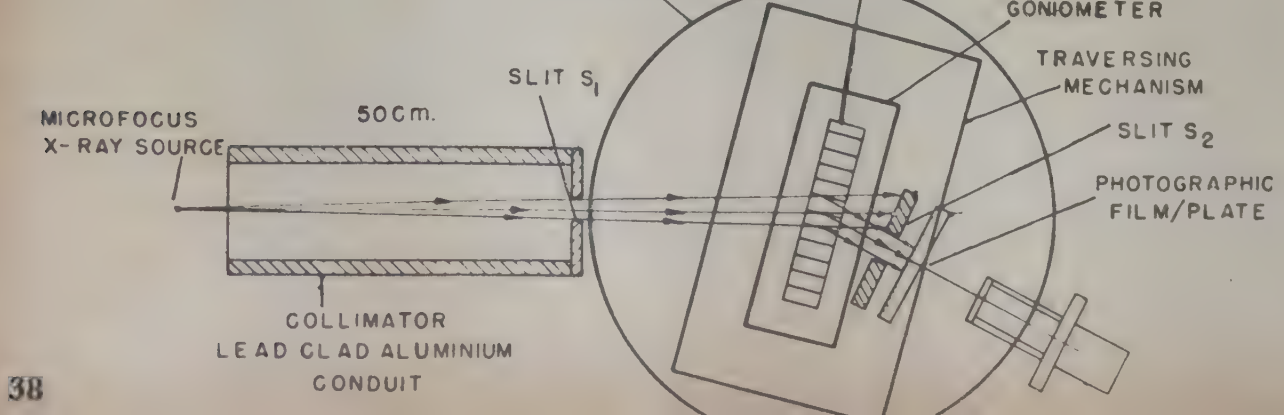
Normally it is not possible to se point defects by X-ray diffractio topography, though large aggregat of point defects can be seen.

The team of scientists which deve loped this technique at the NP consists of Dr. Krishan Lal, Mr. D. R Pahwa, Mr. Vijay Kumar and Mr Keshav Aggarwal. This work wo them the first award of Rs. 6,00 among the NRDC 1977 Republic Da Awards for meritorious inventions.

KRISHAN LA

[Dr. Krishan Lal is Assistant Director National Physical Laboratory, New Delhi.]

A schematic diagram of the X-ray topography camera



New uses for hydrides

THE realisation that conventional fuels are adding large quantities of CO, CO_2, NO_x and SO_2 and hydrocarbons to the atmosphere has led to a keen search for clean fuels. One of the most promising candidates is hydrogen, which produces relatively small amounts of

NO_x and practically zero CO, CO_2 or SO_2. The technology of producing hydrogen from hydrocarbons, coal or by electrolysis of water has been perfected over the last several years, but its storage has so far remained a problem. Storing hydrogen under pressure is very expensive, in terms of capital as well as operating costs.

A new method (*Chem. Engg.*, **84** (19) 98, 1977) uses metals to store hydrogen. The metals selected are capable of forming hydrides under moderate pressure (1 to 2 atmospheres). These metals are capable of taking up some hydrogen in their crystal structure. Several hundred metal alloys are capable of forming metal hydrides under moderate temperature and pressure at rates fast enough to make them useful for storage of hydrogen. The alloys which are promising are magnesium-nickel, iron-titanium, lanthanum-nickel, misch-metal-nickel (misch metal is a crude mixture of certain rare earth metals), and combinations of these metals.

To convert alloys into hydrogen reservoirs, the alloy formed from a melt is mechanically crushed and activated. The activation process consists of forcing hydrogen into the surface of the alloy particles at a high pressure and sometimes a high temperature. One or more such activation treatments leave the powder ready for use over and over again for quick uptake and release of the gas. Hydrogen occupies the interstitial spaces within crystal structures. The hydrogen absorption and desorption depend on pressure and temperature. For lanthanum-nickel, absorption takes place at about 1 atmosphere, at near-ambient temperatures. When fully saturated, the material holds about six atoms of hydrogen per molecule of metal alloy, which on a weight basis comes to about one per cent. This is twice the weight of hydrogen storable in a cylinder in liquid form.

In addition to storage, other applications of hydrides under consideration are: hydrogen utilisation as a fuel for vehicles, gas compression, solar heating and cooling, gas purification, power load levelling and catalysis. Some of these applications employ hydrogen as fuel, others use it as working fluid, cycling between different temperatures and pressure.

An automobile operated on hydrogen has actually been test-run. Tests conducted so far show that the hydride-driven cars roughly match battery-driven cars in weight and mileage. About the farthest these vehicles can go without recharging is 100 km.

Hydrides offer a method of compressing hydrogen without moving parts. Activated metal in a container or cylinder when exposed to hydrogen at low pressure takes up the gas. The cylinder is then capped, heated and finally uncapped to release hydrogen at higher pressure. Adequate cooling of the bed during the initial hydriding step carries away the heat of formation, so that pressure remains low. This heat is reintroduced after capping. This procedure can give output pressure of as much as 120 atmospheres, starting from 1 atmosphere.

In the area of gas purification, the generation of hydrogen from coal has acquired interest. The idea is to perform gasification and a water-gas shift reaction ($CO + H_2 \rightarrow CO_2 + H_2$), pressurise to 20 atmospheres, followed by acid gas removal. A final step is selective removal of hydrogen by exposure to a hydride-forming alloy. The main problem in this scheme is passivation of the alloy by impurities.

In most power plants, utilisation of full capacity for all the 24 hours is not possible because the loads vary at different hours. The power plants have to be designed to the maximum power requirement of any time and the extra capacity remains idle the rest of the time, since electricity cannot be economically stored. One of the approaches is to provide an electrolytic unit to convert the extra power produced during slack hours into hydrogen, store it and utilise it during the peak hours to generate power. Hydride cells in these situations may prove useful. An iron-titanium canister was coupled with a fuel-cell tested hydride for utility peak shaving. The unit went through 60 cycles of absorption and desorption without any difficulty.

A few off-beat applications of hydrogen are also in the offing. One idea under development is to use a metal hydride canister as igniter for domestic gas ranges. When a stove needs lighting, the canister's valve is opened, hydrogen flows out and auto-ignites as it passes through a catalytic initiator touching off the gas flow to a burner. One canister may give as many as 100,000 ignitions, enough for the life of an average stove.

V. C. MALSHE

This toothbrush is a tongue-cleaner, too!

A NEW toothbrush designed at the National Institute of Design, Ahmedabad, combines the functions of the toothbrush and the tongue-cleaner, eliminating the need for a separate tongue-cleaner. Made of heat-resistant thermoplastic by the injection moulding process, the brush has several new features. One end of it has a scraping part to clean the tongue. Its edges are rounded to avoid hurting the tongue. The design is well integrated and smooth, avoiding any sharp corner or pointed end which may hurt the sensitive parts of the mouth, and ensuring efficient cleaning of the brush after use. The base of the bristles is slightly curved so that dirt does not accumulate at the roots.

The cross-section of the body of the brush is 'U'-type instead of the usual solid rectangle. A 'U'-type cross-section is much stronger (it also uses less material). This minimises the chances of breaking at the neck. Existing tooth brushes often break at the neck because the cross-section there is the smallest, while the force acting on this part during brushing is the maximum.

With the material saved, the body of the brush is made wider, providing a comfortable hold. The brush can be hung conveniently at any place. The product is only at the prototype stage.

S. BALARAM

let's get to know our trees!

Trees of the Coastal Regions

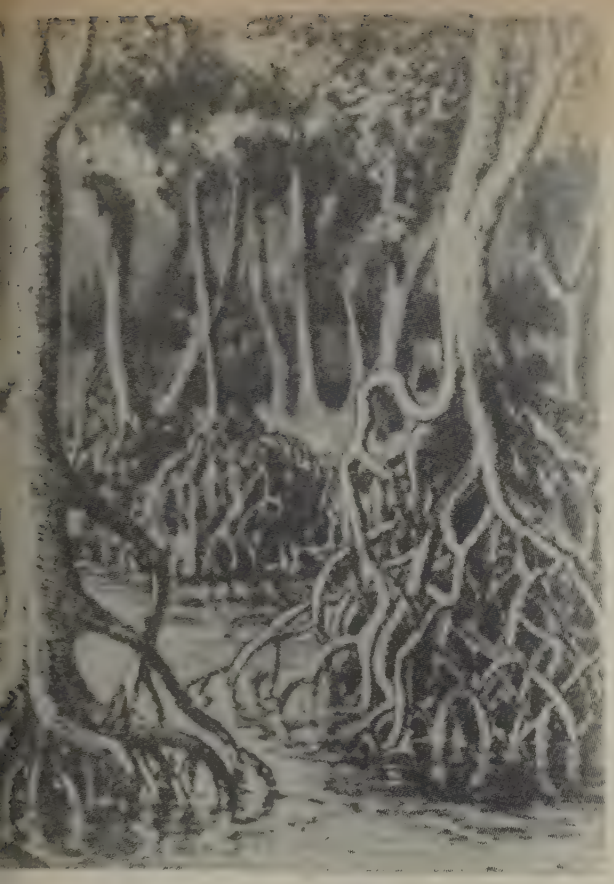
THE sea coast, which in our country measures about five thousand kilometres, is a unique region where two entirely different environments meet and clash endlessly in a rather narrow zone. On the one hand is the salt water of the limitless oceans constantly clawing the shores, and on the other, the land mass with its load of fresh water replenished from time to time by the rains and the flowing rivers. This transitional zone between these extremes, also known as the littoral zone (from the Latin *litoralis* — pertaining to the seashore), is indeed a hostile place for most trees which are adapted to absorb nutrients and fresh water from the ground. However, some plants like the mangroves have evolved and developed structures and mechanisms for survival in the face of such odds as high salinity and turbulent weather conditions. Indeed they thrive only in the tidal zone and on the mudflats near the sea and would wither if transplanted inland. Such salt-tolerant species are called halophytic plants (from *hals*, Greek for salt, and *phyton*, a plant).

The dense woodland formation of the mangroves is often the first vegetation to greet visitors to outlying islands or the coasts as they approach a pier jutting out of the mudflats. The mangrove family of plants (Rhizophoraceae) can be easily recognised from the numerous stilt-roots which arise from the trunk and grow slanting downwards and anchor the tree to the muddy substratum — much in the same way as a photographer's tripod does. The mangrove also has large numbers of interlacing roots just above the ground which trap gravel and mud along with weeds, thus permitting a slow but sure advancement of the land in a seaward direction. The masses of these roots often form impenetrable thickets which further reduce the impact of oncoming waves by acting as a barrier and also by scattering them and thus dissipating their energy. The name of the family is derived from this feature and means "root-bearer" from the Greek *rhiza* (root) and *phoros* (to carry or bear). Another feature of the mangrove, which is easily observed especially at low tide, is the possession of pneumatophores (meaning breathing roots). These are vertical, pointed and corky growths from the roots pushing upwards out of the ground; they serve as additional devices for absorbing oxygen from the air (

A typical representative of t family is the true mangrove (*Rhi phora mucronata*), known as **kamo** Hindi. Usually a moderately-siz evergreen tree growing in all coas belts, the kamo attains an imme size of 25 metres in height and a gi of over a metre in the Andamans a the Sundarbans. The dark trunk w a horizontally fissured bark is topp by a dense green canopy of clos set branches and thick leaves. T leaf is variable in size but is genera less than the size of one's palm; it thick, smooth and leathery in textu elliptical in shape and ends in a abrupt point which is somewhat har Like other mangrove species, t kamo leaf has a system of trache (tubular structures) for storage

A casuarina t

S. R. Nayak



angroves showing stilt roots

ater; the thick cuticular surface is nother adaptation which prevents ater loss through transpiration. The wer surface of the leaf is paler than ie upper and is dotted with minute ark-coloured spots. Small greenish-hite flowers appear during the nonsoon in threes in the axils of eaves; the sepals and petals are short, eshy, hairy and are very closely rapped. Each flower develops during ugust and September into a one-eeded conical berry about five cen-metres in length and dark brown n colour.

A peculiarity, rarely seen in other pecies, is the phenomenon of vivipary meaning bearing of live young ones – a term borrowed from zoology): ie fruit remains on the tree for a ery long time, sometimes for months, ipens and the seed germinates while he fruit continues to cling to the arent plant and draw nourishment rom it. The germinating embryo nay reach a full 40 centimetres or nore before it gets detached and loats away to strike root in the mud lsewhere. This feature is again an daptation to the high salinity. The oung embryo first concentrates a arge amount of salt while on the arent so as to enable it to absorb water from sea water by osmosis later. It is not uncommon, therefore, to see hese long embryos dangling from the ranches of the kamo tree; one may, n fact, mistake them for fruits. Kamo eaves and fruits are eaten by cattle, nd tender leaves are used sometimes s a vegetable. Its wood is straight-grained, hard and dark red in colour; it is sometimes used for making small utility items, but is more generally used as fuel and for making charcoal. The bark is rich in tannins and is extracted for use in the leather indus-try, and its ash, rich in lime content, is used as a fertiliser.

(Right): Ovoid fruit of *Rhizophora mucronata* (true mangrove) with the radicle growing out of its lower end

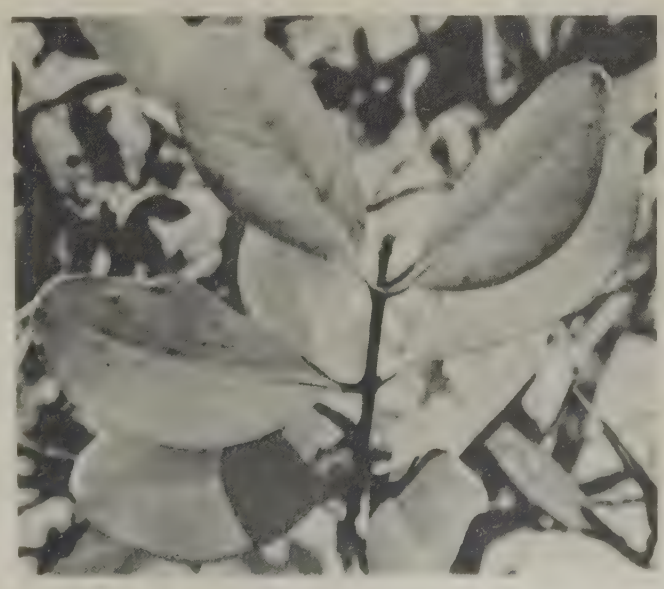
The coastal mangrove forests are a place for some surprises for, besides the true mangroves, some trees belonging to unrelated families, too, have adapted to the salt marshes and for all practical purposes are referred to as mangroves. Two such trees are the **archaka** (*Sonneratia caseolaris*) and the **bina** (*Avicennia officinalis*).

The Sonneratia species is a small- to medium-sized tree with thick evergreen leaves. It is distributed all along the Indian coast, freely interspersed among the true mangroves. Under suitable conditions, the tree does reach a good height of about 20 metres, especially in the Andamans. The bark is dark brown and relatively smooth and covered with many lens-shaped pores bordered by corky lips (lenticels). The leaves are ovate and have rounded tips and very short and thick stalks which are tinged with red in tender leaves, quite unlike those of the Rhizophora. One also notices the absence of prominent supporting stilt roots though pneumatophores are present. The pneumatophores are thick and corky.

What sets the Sonneratia apart from the true mangroves is the difference in the floral structure: its large flowers have a shallow tubular calyx with four to eight lobes, and corolla with six purplish petals and tufts of many stamens which thrust out of the flower. The floral structure closely resembles that of the family Lythraceae (an example is Queen's flower) in which it could be placed; botanists, however, have erected a new family, Sonneratiaceae, to accommodate this genus whose closest relatives are all land-locked plants. It flowers from March to July.

S. R. Nayak

(Above) Salt marsh mangrove with breathing roots. Actually two species of trees can be found here: (*a*) the Sonneratia and (*b*) the Avicennia. (Below, left): Sonneratia leaves with thick and rounded apex, and (below, right), the acutely pointed Avicennia leaves



S. R. Nayak

S. R. Nayak

A Sonneratia fruit floating in sea water

The archaka fruit, which develops in October and November, is a berry with many seeds embedded in an edible acid-sour pulp. The cushion-like fruit is closely hugged by the cup-like calyx and readily floats on water after detachment from the parent tree. Another difference seen is the rarity of vivipary — in fact, close observation of the shore reveals the tiny seedlings coming up on their own among the salt-tolerant grasses, in the blades of which the small crinkly angular seeds were trapped.

Archaka wood, a shade of reddish grey, is soft and used mainly as fuel. The wood contains two anthraquinone colouring substances, archin and archinin. The bark contains over 10 per cent of tannin which is utilisable. The fruit pulp contains pectin and a jelly can be made from it. The thick pneumatophores are used as a substitute for cork.

The **bina** or **baen** tree is another common associate of the coastal mangrove complex. Like the archaka, it too has no stilt roots but possesses pneumatophores. It belongs to an entirely different family, Verbenaceae, to which the teak tree also belongs.

This Avicennia species is a rather moderate-sized evergreen tree with a smooth greyish-green bark and a heavily branched crown of brilliant green leaves. Each leaf is thinner than that of the foregoing two species, measuring about five centimetres long and about half as broad with a slightly tapering and pointed apex. The upper surface is smooth and bright green while the lower surface appears silvery-white owing to a covering of fine downy hair. The flowers which appear from March to June occur in small clusters on three-branched stalks; the small yellow petals consist of five lobes united to form a tubular corolla. The fruit is a five centimetre long oval, flat and beaked capsule; it opens into its two constituent valves exposing the single seed it contains; the seed germinates on the parent tree from July to August and even later.

Bina leaves are eaten by livestock. The seed kernel, though bitter, is edible. A green bitter aromatic resin from the bark is claimed to have medicinal value as an astringent, and the root is believed to be aphrodisiac.

Where the sea has held sway over the land unopposed as on open beaches directly exposed to wave action, the shore is predominantly made up of sandy stretches. Here some hardy trees which are less salt-tolerant than the mangroves, but certainly more so than their cousins further inland, strike root and gain sustenance from the ground water. These trees generally grow above the high water mark and do not seem to be affected by occasional salt sprays from the sea.

One such outstanding coastal zone tree is the **sea oak,** or **suru** in Hindi (*Casuarina equisetifolia*). The suru tree was introduced into the Calcutta Botanical Garden in 1798, and since then has been grown and nurtured all over the country, especially in the coastal regions. Vast stretches of our beaches have been beautified by plantations of casuarina which can be considered to be naturalised in India.

The general appearance of the casuarina, which can attain an imposing height of over 30 metres and a girth of 5 metres, is reminiscent of the leafless pine tree. Its side branches droop slightly and the final branchlets are only slender green cylindrical filaments, a couple of millimetres in diameter, at the joints of which extremely minutes scales are seen — these really being the tremendously reduced leaves (it requires a m fying glass to examine these de The flowers are unisexual an flowering time is heralded b appearance of the male and f flowers on the same tree. It challenging exercise to pluck examine especially the male f clusters because they appear as rusty granular masses at the of the filamentous branchlets minute flowers, and that, too, wi petals and only a single stamen often overlooked. Lower down o branches, the female spikes of flo appear as peanut-sized cones more familiar sight to most pe The scale-like bracteoles near flower enlarge and become wood enclose the winged nut (the fruit) inside; the commonly kn " fruit " of the casuarina is, there composed of many of these struct held tightly together and looking a thumb-sized hard jackfruit.

The casuarina rarely germin naturally and has to be regener from seeds carefully nurtured. most important economic use of casuarina is as fuel; the logs b slowly and retain heat and em for a long time. According to B hill, it is the best firewood in world. The hard wood of this ra growing tree is sometimes used posts, boat masts and the like. Perh the most effective use of the casua is in soil conservation: when m planted on sandy shores, its nee like filaments are cast off as they and form a thick interlacing ca on the ground; this enmeshes sand grains and this, together w the dissipation of the energy of wi blowing through its branches, preve the inland drift of the sand and w it the sea. Other species of plants then be planted in the same area. casuarina, with the wind sigh

S. R. N

Close-up of a casuarina fruiting branch and filamentous branchlets

alophyllum inophyllum or punnaga — leaves and bunches of white flowers S. R. Nayak

hrough its branches, has also inspired Rabindranath Tagore to write a poem on the tree.

The botanical nomenclature of he tree is worthy of note — if only to ecognise the essence of poetry even in he choice of a scientific name! *Casuarina* is derived from *casurius*, the Latin ame of the flightless Australian bird, he cassowary, whose feathers are educed to mere filamentous tufts; *quisetifolia* means "leaves like a orse's tail".

This tree can be grown and trimmed, and its size kept small enough, o serve as a hedge plant, especially n road centres to divide the two anes. The casuarina is also believed o represent a link between the Gymnosperms and the Angiosperms n the evolution of trees.

An extremely beautiful evergreen tree of the coastal egion found on the sandy shores of he Indian peninsula is the **Alexandrian laurel** (*Calophyllum inophyllum*). Known to the ancients as **punnaga** or *panchakeshara* in Sanskrit, it has been mentioned by Valmiki; its Hindi name is *sultan-champa*.

The punnaga is a fairly large tree with beautiful dark green foliage. Each leaf is as large as one's hand, thick, smooth, with a rounded apex and a thick central midrif from which close-set parallel veins run to the margins of the leaf. This spectacular yet simple design of punnaga leaves is what inspired the botanical name *Calophyllum* (beautiful leaf) *inophyllum* (thread-veined leaf). The exquisite foliage is a fair compensation for the thick, short, black trunk with a rough and scaly bark.

Curiously, the flowering season of punnaga varies — the summer in some parts of India and winter in others. The four-petalled white flowers, with many stamens and a single ovary, appear in bunches of a few flowers each and are sweet-smelling. Throughout the day large numbers of bees and insects converge on the flowers. The fruit is a round, single-seeded drupe, green when raw but acquiring a yellow colour on ripening. The pulp of ripe fruits is a favourite food of bats which knock down many half-eaten fruits at night.

The punnaga yields a strong brownish timber which can withstand water and is used for construction of posts, carriages, boats, etc. Incision of the bark yields a yellowish-green translucent gum with emetic and purgative properties. The dark green seed oil, about 60 per cent by weight, has a disagreeable odour; it is used mainly as an illuminant, and in indigenous medicine it is rubbed on the skin for rheumatism, and applied locally to treat scabies. Some phenyl-coumarin compounds (neoflavonoids) have been isolated from the oil; of these one compound, known as calophyllolide, has been shown to depress the heart and prevent coagulation of the blood. The seed oil mixed with other plant resins is used by coastal villagers for caulking boats.

One of the most popular roadside trees in some of our cities, especially those near the sea, is the **Indian tulip** tree, or **bhendi** in Hindi (*Thespesia populnea*). Known as *gardha-bhanda*, *parisa* or *suparashvaka* in Sanskrit, it is also called **paraspipal** in most Indian languages. The common name, bhendi, derives from the fact that its large yellow, five-petalled flowers with a dark purple-brown centre have a strong resemblance to the flowers of the edible vegetable (*okra*) which belongs to the same family, Malvaceae.

The evergreen bhendi tree is a native of the coastal regions of tropical Africa, Asia and the Pacific islands. Though a maritime species, many trees may be seen planted as far inland as the Deccan plateau on the raised embankments of fields and around temples. It was this latter fact that was responsible for the botanical name: *Thespesios* means divine, and *populnea* is an allusion to its leaves which resemble those of the poplar. The bhendi leaf is about as large as one's hand and heart-shaped with the stalk attached to the rather deep cleft between the two halves; the leaf tip tapers to a fine point, and the five to seven nerves radiating from the petiolar attachment can be clearly seen. The tree flowers throughout the year. The fruit is a five-celled capsule, containing flat ovoid seeds

Thespesia populnea or bhendi. (Below) Close-up of a flower. (Right) Leaves and a fruit

S. R. Nayak

(Above) *Barringtonia racemosa* flower and (right) leaves and a fruit

and capped at the base by the persistent cup-like calyx.

The bhendi tree sheds a few leaves at a time and these turn yellow as they age; so most of the year the green canopy of the tree is splashed with yellow in patches. The flowers, too, change colour with age, the older ones turning a dull red before dropping. The tree can be raised from seeds as well as from cuttings, but seed-raised ones are straighter and yield wood of a better quality than those raised from cuttings.

The heartwood of bhendi is rich brown in colour and strong enough for making carts, carriages, gunstocks and other utility items. For this reason, it is also called the ' false rosewood '. The leaves are used as livestock fodder. It is reported that the young buds and leaves along with flowers may be eaten raw or cooked.

The bark of the bhendi gives a rough fibre used as cordage; the fruits yield a small amount of a deep red oil. The flowers and fruits can be extracted to yield a yellow dye ; this was used at one time to colour silk and wool. Village children cut open unripe fruits and use the bright yellow pulp as a water colour. The coloured compounds are mainly glycosides of kaempferol; the plant contains another chemical compound, gossypol, which is also found in the cotton plant (which belongs to the same family).

Roadside herbalists often include the paraspipal fruit in their wares; it is used in indigenous medicine for treating skin diseases. Alcoholic extracts of bhendi fruits have shown some antiviral and anticancer effects in laboratory animal tests.

In the Hindu religious ceremony of Gauri puja, bhendi flowers are used as an offering in the belief that the goddess prefers yellow flowers; the flowers are also offered during Ganapati puja.

S. R. Nayak

The sea coast is the home of yet another medium-sized species of trees — the Barringtonia of which at least three species are found in India. *Barringtonia acutangula*, aptly named *samudraphal* (" fruit of the sea ") in Hindi, is an evergreen tree which has a dark thick trunk with a deeply vertically furrowed corky bark in the more mature specimens. It is known as *hijjal* or *dhatriphal* in Sanskrit.

The **hijjal** leaves are closely crowded together on the branches and thus make a good shade tree. Each leaf is long and elliptical, narrower at the base and broadening to a rounded apex and has a slightly serrated margin. The leaf is much smaller than its cousin's, *Barringtonia racemosa* — a favoured shade tree which has broad 30 cm-long leaves. The flowers are small, less than a centimetre across, and arranged in long hanging racemes, about 25 to 30 centime long, at the ends of the branc The four-petalled flowers with centre of many red stamens look little pendants hanging from a bro chain. These flowers appear in hot season, and on the west coas December and January. The centimetre-long fruits emerge fr the drooping branches a short t later. Hijjal fruits are four-ang and at the far end have four fle knobs each. For ornamental planti *B. racemosa* is more often cho because of the large green lea and the big showy flowers — eac Goliath when compared with diminutive flower of *B. acutangula*

Hijjal bark contains over 10 per c of tannin which can be extract native folk use the crushed bark stupefy fish in streams and pon The leaf juice is used in diarrho and also as a bitter tonic. The t contains triterpene saponins wh are irritant and toxic; root and ba extracts have a depressant action the nervous system of laborato animals, and the stem bark is report to have an anti-amoebic action.

Despite the rather monotono aspect of mangrove woodlands, closer look at them cannot fail impress us: they halt the erosi caused by the sea, help to form n land by reclaiming the shores, provi a haven for smaller creatures li the fiddler crabs, mud skippers a others, provide safe roosts for wadi birds and migrants, and above provide a classic example of ho evolution proceeds to adapt diver types of plants to a similar style life in an extraordinary milieu.

S. R. AMLAD

(Left) *Barringtonia acutangula* — hanging inflorescences with small flowers. (Right) *B. acutang* fruits

S. R. Nayak

The Coiled Serpents From The Sea

A. K. MUKHERJEE

YCLONE means the coiling of a snake. This word, derived from the Greek, was first coined in India about a undred years back by Henry Piddington of Marine Court, Calcutta, o describe the tropical revolving torms so frequent on the Bay of engal and the Arabian Sea. Today, ne term is used in a more generalised ense. Whenever wind blows from all irections towards a point, it executes coiling motion. This is called a yclone.

Let us assume there is no disturbance in the atmosphere. Air will nove in a practically straight path vith respect to the surface of the earth. f over a certain area pressure falls, ir from all directions will move owards that area. Rotation of the arth does not allow the air to go traight but exerts a deflecting force, nown as Coriolis force. Over the Northern Hemisphere this deflection s towards the right and over the outhern Hemisphere it is to the left. Or, in other words, if we put our back o the wind, we should get the low ressure to the left over the Northern Hemisphere and to the right over he Southern Hemisphere. This is he famous Buys-Ballot's law. From his concept it can be shown that air ushing towards a place with low ressure will approach it as a coil vith anti-clockwise motion in the Northern Hemisphere. In this article ve shall discuss cyclones over the ropics, particularly in the Indian area.

The speed of wind depends on ressure gradient. Thus, the deeper the ow pressure, the greater will be the peed. Hence, meteorologists call low ressures of different intensity by different names as they represent different intensities of air flow and ence different intensities of weather henomenon. Though the common ame of these systems is cyclone, in ctual practice Indian meteorologists designate only the stronger systems by his name. The circulations of air n all these systems are similar and are referred to as cyclonic circulations. In India we follow the following nomenclature for different systems:

Name	Wind (actual or inferred)
1. Low pressure area	up to 16 kt
2. Depression	between 17 and 27 kt
3. Deep depression	between 28 and 33 kt
4. Cyclonic storm (moderate intensity)	between 34 and 47 kt
5. Severe cyclonic storm	between 48 and 63 kt
6. Severe cyclonic storm with a core of hurricane winds	64 kt and above

1 kt (knot) or nautical mile = 1·85 km

Condition for formation

Energy for all sustained weather systems is derived from the latent heat of condensation of water vapour. Thus, though low pressure areas or depressions may form both over the land and the sea, they will not be sustained unless enough of water vapour is available. It is only under exceptional circumstances, that is to say, during monsoon season depressions, that even cyclonic storms may form over the land. However, these cannot reach the severe cyclonic storm stage. Otherwise, cyclones form over the sea and move and often hit the land that lies in their path. After the system enters land, it weakens as there is very little moisture supply now and also due to friction of the

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land surface. Since initial formation of a tropical cyclone is practically always over the ocean areas with few or no permanent meteorological stations, it is natural that the first stages of development should be less known than the mature stage when the cyclones penetrate into the dense network of meteorological stations.

In spite of the fact that the necessary conditions for formation of tropical cyclones are often present in large areas of the earth during certain seasons, the actual appearance of cyclonic storms is a relatively rare phenomenon — only about 50 such storms are observed per year over the entire globe. This indicates that there must be a rare coincidence of circumstances before a cyclone of severe intensity can develop.

The necessary conditions for formation of cyclonic storms are:

1. Sufficiently large ocean areas with the temperature of the sea surface so high that an air mass lifted from the lowest layers of the atmosphere, with about the same temperature as the sea surface, and expanded adiabatically accompanied by condensation of water vapour, remains considerably warmer than the surrounding undisturbed atmosphere at least up to a level of about 12 km.

2. The value of the Coriolis force should be larger than a certain minimum value. Since the Coriolis force is directly proportional to the sine of the latitude of the place, the area between 5°N and 5°S latitudes may be safely excluded.

3. Vertical wind shear in the basic current should be weak enough to allow the latent heat liberated in the area to remain there and thus help further development.

4. When air moves towards a low pressure area, that area should be filled with the air and thus the 'low' will be destroyed. To maintain the system, therefore, the air in the upper level should be pumped out. Thus, we should have a convergence in the lower level and a strong divergence at the upper level.

Condition (1) demands that a warm sea surface is necessary. It has generally been agreed by meteorologists throughout the world that sea surface temperature should be at least 26°C for a cyclonic storm to form over the area. And, condition (3) indicates that such severe cyclonic storms can form over the tropics only. Experience has shown that once a tropical cyclone has formed, it is a very persistent phenomenon as long as it remains over warm seas. This indicates a fundamental difference between tropical and extratropical cyclones, namely, that of their source of energy. Most extratropical cyclones remain for only a short time at the maximum energy level, degenerating almost as rapidly as they are formed.

Condition (4) can be said to be a fundamental condition for the development of all cyclones. Tropical cyclones form over ocean areas where at least some observations from ships can be obtained. Though sometimes the lower convergence condition can thus be detected, the condition for upper divergence is extremely difficult, if not impossible, to determine. This puts a serious limitation on the forecaster's job.

Climatology

Fig. 1 shows the principal paths of tropical cyclones together with the sea surface temperatures during the warmest season. It may be seen that the whole of the South Atlantic Ocean, the eastern parts of the South Pacific Ocean and the central parts of the North Pacific Ocean are too cold to permit the development of cyclonic storms even during the warmest season. During the cold season, some rare cases of tropical cyclones are registered over the Pacific Ocean and the Indian seas near the equator where the sea surface temperature remains high.

The conditions over the north Indian Ocean, that is, the Indian seas, are quite different from other areas. Strong influence monsoon prevents the formatio tropical cyclones, specially the se ones, since the condition (3) st above becomes unfavourable. severe cyclone season is, there limited to May–June and Octo November. It may also be seen the travel over the sea before lan (that is, before striking the coas short compared to other areas in world. This, again, poses a ser limitation to the forecaster as much time becomes available to to warn the people about the impe ing danger.

Table 1 gives the average num of storms and depressions over Bay of Bengal and the Arabian in the different months of the y The total number in a year is, on average, 13 over the Bay of Ben About one-third of these inten into storms, 30 per cent of wh attain severe intensity. Even tho the annual number of cyclonic turbances over the Arabian Sea much less (2·36), a larger proport of them attain higher intensity. Ab half of the Arabian Sea depressi intensify into storms and nearly per cent of the latter become sev

The annual variation of all cyclo disturbances over the Bay of Ben shows a single maximum in Augu September, like the disturbances the North Atlantic and North Pac Oceans. On the other hand, annual variation of the cyclo disturbances (both storms and pressions) over the Arabian Sea sh double maxima, in October–Nove ber and in May.

The yearly profile

Tropical storms the Indian seas originate between 5 and 22° N. The places of origin migr north and south, following the parent north-south movement of Sun. Cyclonic storms are rare in Indian seas from January to Mar

Fig. 1 The principal hurricane paths (coloured arrows) and surface water temperature (in centigrade) during warmest season

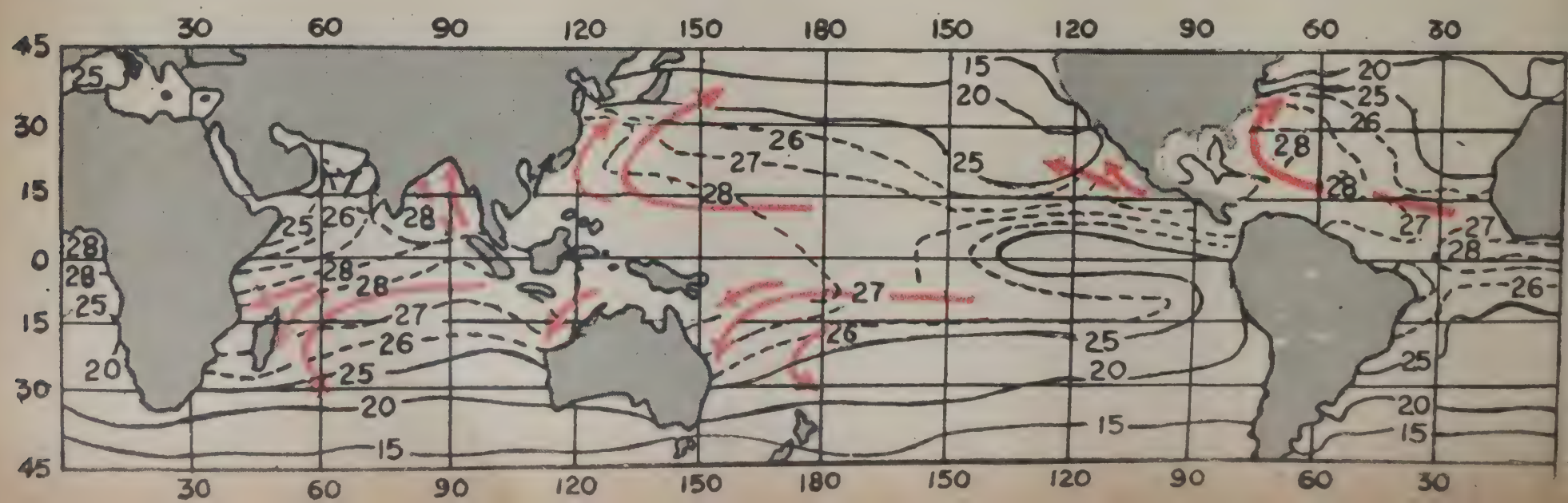


TABLE 1: AVERAGE NUMBER OF STORMS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
						Bay of Bengal							
Depressions & Storms	0·19	0·04	0·07	0·37	0·80	1·33	1·89	2·07	2·16	1·89	1·46	0·74	13·00
Storms	0·06	0·01	0·06	0·26	0·40	0·49	0·54	0·36	0·39	0·76	0·80	0·37	4·49
Severe Storms	0·01	0·01	0·03	0·10	0·26	0·06	0·10	0·01	0·11	0·27	0·33	0·13	1·43
						Arabian Sea							
Depressions & Storms	0·07	—	0·01	0·10	0·29	0·43	0·16	0·03	0·14	0·51	0·50	0·11	2·36
Storms	0·03	—	—	0·07	0·19	0·19	0·04	0·01	0·06	0·24	0·30	0·04	1·17
Severe Storms	—	—	—	0·06	0·16	0·11	—	—	0·01	0·10	0·23	0·01	0·69

The few that form over the Bay of Bengal originate between 5°N and 7°N. The region of formation shifts to the latitudinal belts 8°N to 13°N in April, 10°N to 20°N in May and 16°N to 21°N in June. During July and August, the storms form over the Bay of Bengal between 18°N and 22°N. (They are almost absent in the Arabian Sea during these months.) With the progressive southward shift of the Sun, the source region shifts to the sea area between 15°N and 21°N in September, 8°N and 18°N in October and 6°N and 14°N in November and December.

In April and May the Bay storms move initially northwest or north and later recurve northeastwards. In April, the recurvature takes place over the seas and the storms strike the Arakan coast. In May, the whole east coast of India, coastal Bangla Desh and the Arakan coast are vulnerable to the incidence of storms. Most of the June storms move northwest and cross north Andhra, Orissa and the West Bengal coasts. In July and August, the movement is towards west-northwest across the Orissa and West Bengal coasts. The tendency for recurvature begins to increase from September. Most of the storms of October and November recurve, the former near latitude 18°N to 21°N, and the latter near 15°N to 18°N. Andhra, Orissa, West Bengal and Bangla Desh are more prone to the incidence of storms in October while Tamil Nadu and Andhra Pradesh are more vulnerable in November. The storms of December that form over the southwest Bay move westnorthwest and cross the Tamil Nadu coast while those that form farther east move northwest and later recurve to the north and weaken over the sea.

May storms of the Arabian Sea generally move westwards and cross the Arabian coast. Those in April, October and November move initially northwest and later recurve to the north or the northeast. Gujarat and north Maharashtra coasts are the vulnerable areas.

Structure of tropical cyclones

A tropical cyclone has a very low pressure at its centre. In meteorology, pressure is expressed in millibars (mb), 1 mb being equal to 1000 dynes/cm.^{2} Normally, one atmospheric pressure is calculated as 1013·2 mb. Around the low pressure centre we get some closed isobars. In India, meteorologists draw isobars at intervals of 2 mb (it's a normal practice to draw isobars of even mb values). In a moderate cyclone, the pressure fall from the undisturbed atmosphere, that is, where the isobars are not closed, roughly over a distance of a few hundred kilometres is between 13 mb and 18 mb. For a severe cyclone the minimum pressure deficit should be more than 18 mb.

Due to deficit of pressure within a short distance, the pressure gradient is high and hence wind movement is very strong. As the wind moves spiralling towards the centre, it comes under the influence of upper divergence and the air goes up before reaching the centre. For a mature severe cyclone, therefore, we get the following wind structure over the surface:

Wind speed αr, up to a certain distance R;

Wind speed $\alpha \frac{1}{r^{0.6}}$ beyond a distance R′

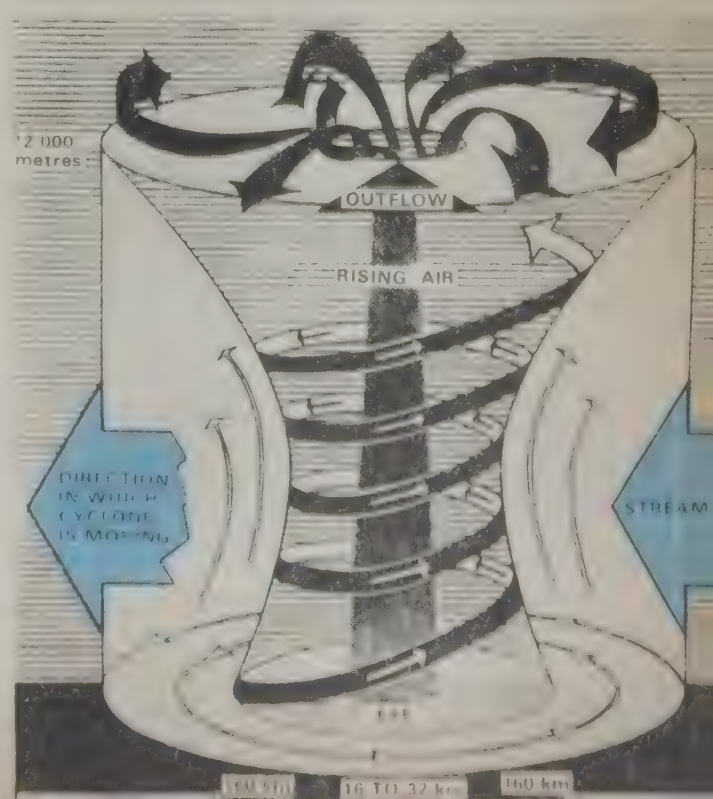
where r = distance from the centre and R and R′ are two fixed distances from the centre and R′ > R. The space between R and R′ is called the eye wall. The region where the speed is directly proportional to distance is the eye region, where a downward motion is found to exist (and as a result the sky is clear). In the eye wall, the wind is strongest and upward motion is maximum and hence this region gets extremely heavy rain and very thick clouds. Outside the eye wall, there will be strong upward motion of air and hence clouds and rain. The clouds appear in bands.

All theoretical studies assume that the tropical cyclone is symmetrical. In actual practice, cyclones are found to be non-symmetrical. This can be very prominently seen over the Indian seas. Fig. 5a shows the speed of wind over sea around a severe cyclone (Gopnath cyclone, 1976; in India, a cyclone is named after the place on the land it hits) as observed by the author. Incidentally, such detailed observations are very rarely possible (see box on p. 50). The only other observation available in scientific literature was by Arakawa and Suda when in 1935 the Imperial Japanese fleet inadvertently entered into a typhoon.

Destructive features

The typical cyclonic weather system has a number of destructive features. The first is, of course, wind. Officially, hurricanes have winds of more than 64 kt. In practice, though, we get much stronger winds than this. The Gopnath

Fig. 2 Wind structure of a hurricane



cyclone had 100 kt winds. The Chirala (or Masulipatnam) cyclone of 1977 had 95 kt maximum wind in the eye wall. A cyclone as a system moves with a speed of 10 to 25 kmph. Thus, a cyclone of 10 km-thick eye wall moving with a speed of 10 kmph will affect a place with such strong winds of the eye wall for a minimum period of one hour. Such strong gales accompanied by very heavy rain are extremely dangerous for almost any structure. Broken or twisted telegraph poles and lamp posts often bear testimony to the force of the gales. As we have mentioned earlier, the strongest wind does not exist on all sides. The strongest wind was found to be on the right-rear quadrant in the Gopnath cyclone of 1976, but on the left-forward quadrant during the Porbandar cyclone of 1975. Arakawa found that typhoons have strong winds on both the right-rear and the front quadrants. Thus, even where a rather accurate forecast can be issued about the passage of the eye of the cyclone, the exact sector of strongest gale cannot be forecast.

Heavy rain is the second destructive feature of a tropical cyclone. Quantities of rain in cyclones vary widely. Studies in India reveal that there is a wide variation of heavy rain on different sides of a cyclone. Depressions and moderate cyclones over India during the monsoon give heaviest rain on the left-forward quadrant. Storms over the Bay of Bengal during October also give heavy rain to the left side whereas during November it may be on any side of the storm. Storms of April and May also have very heavy rain on all sides. Because of this uncertain behaviour, the sector of heaviest rain in a cyclone cannot be forecast accurately. Storms of the Bay of Bengal during October also give very heavy rain away from the storm on the right side. Similarly, storms over the Arabian Sea during the dry months of April–May and October–November can give heavy rain over Bombay if they cross land in Saurashtra.

The third destructive feature in a cyclone is the mountainous waves. Waves are caused by action of wind on the water surface. Over the open sea, waves can attain great heights. Measurement of wave heights in a hurricane field is again a difficult task. In India, such accurate measurement was possible only in the case of the Gopnath cyclone — 15 to 16 metres high (see box on p. 50).

The fourth destructive feature is the swell. Waves over the sea can travel long distances if not destroyed by the wind. These waves which originate at one place are called 'waves' at the place of origin but are called 'swells' when they travel and reach another place. Of all waves over the sea, swells carry the maximum energy. They lose in height but gain in period and length as they travel — often some thousands of kilometres.

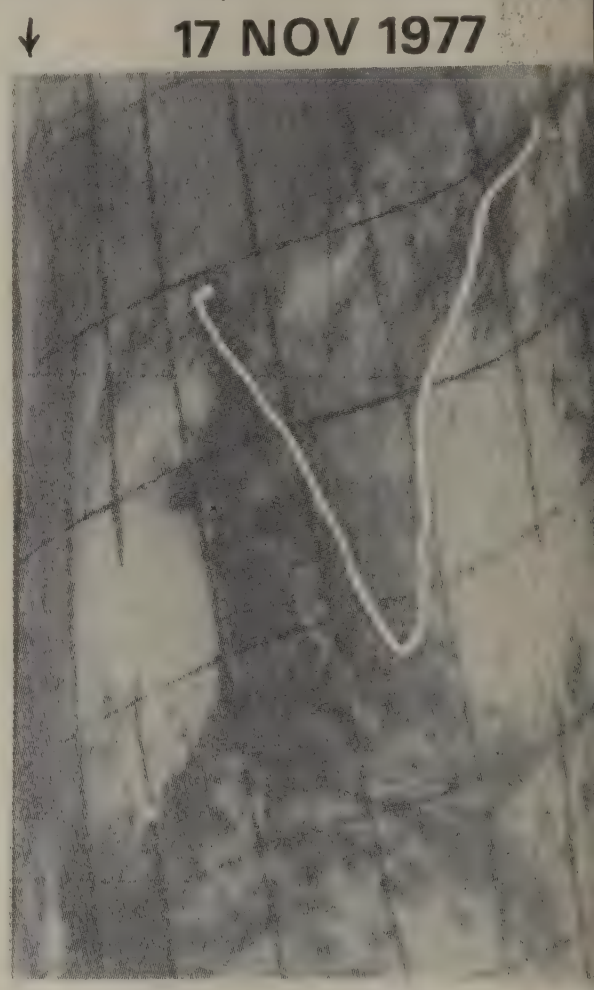
The fifth and the severest destructive feature of a tropical cyclone is the " storm surge " or " storm wave ", popularly but mistakenly called a " tidal wave ". Such surges occur only at the coast. The effect is mainly due to the piling up of water (see SCIENCE TODAY, January 1978, p 53). Intensity of the low pressure system causes water to rise a bit but that is a comparatively less important factor. A surge can occur both during high tide and low tide, but is accentuated if it occurs at the high tide time. Wind blowing over the sea from sea to land causes the water to pile up. The effect is most prominent where the sea is shallow. Since wind movement is in a circular path, only the side where the wind is on-shore will see a storm surge. On the diametrically opposite side, the sea may actually recede. On the east coast the surge will be to the north of the centre of the cyclone, but on the west coast, it should be to the south. On the coast of Bangla Desh, West Bengal and Kutch, the surge is to the east of the centre. Not much data are available for storm surges, but from whatever we know we find that the destructive surge can occur for 20 to 50 km length of the coast. The width of the surge is much less known, but may be a few kilometres across.

After a storm surge strikes the coast, the devastation is very great. Water rushes in with great force destroying everything on its way and inundates vast areas of land. It is, therefore, necessary to know the definite areas which are prone to such destructions by storm surges. As mentioned earlier, the severe storm surges occur where the sea is shallow or where there is a very gentle gradient in depth. In the Indian sub-continent, such areas are found off the Bangla Desh, West Bengal and north Orissa coasts, the coastal area from the mouth of the Godavari to north of Nellore and the east coast south of Pondicheri, the coastal areas around the mouth of the Gulf of Cambay and the Gulf of Kutch.

The distance up to which the inundation can take place depends on the height of the land and the topography of the place. For example, storm surges inundate vast areas on the Bangla Desh and West Bengal coasts where the land is flat and only slightly above the sea level. During a cyclone in 1942, practically the w of Midnapur district in West Be was inundated by the storm surg the height of the land in this dis is only between 1·2 to 1·8 me

Usually, alluvial plains at mouth of rivers are very flat and b very fertile, most of the land is cult ted for cereals. The absence of t and other obstructive features such flat lands allows the storm s to progress unhindered over the l

Storm surges are, in fact, so str that special precautions have to taken against them. In Bangla D some raised earthern platforms h been made in several areas wh people gather when warnings storm surges are issued for those ar In India, no such special arran ments have yet been made anywh



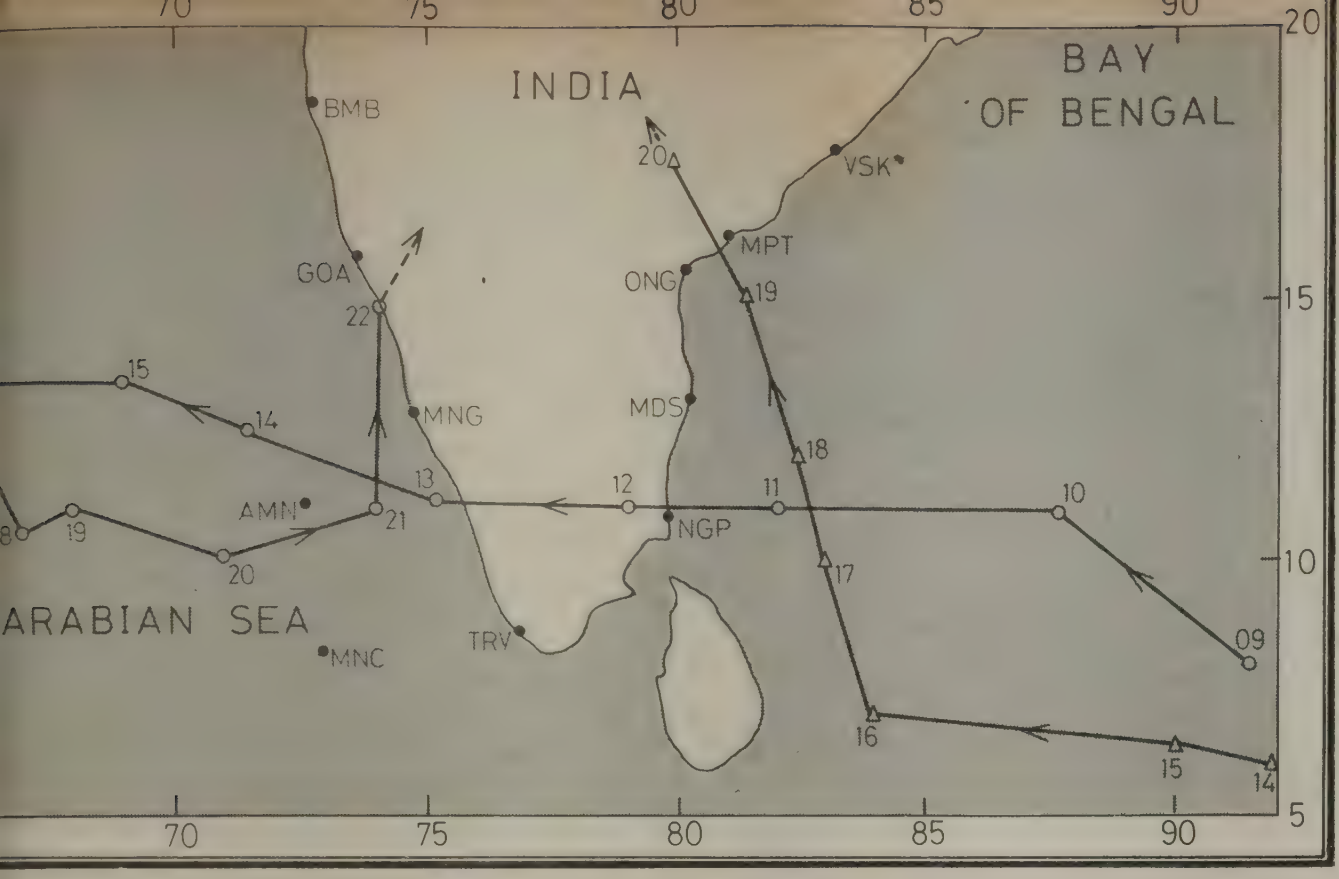
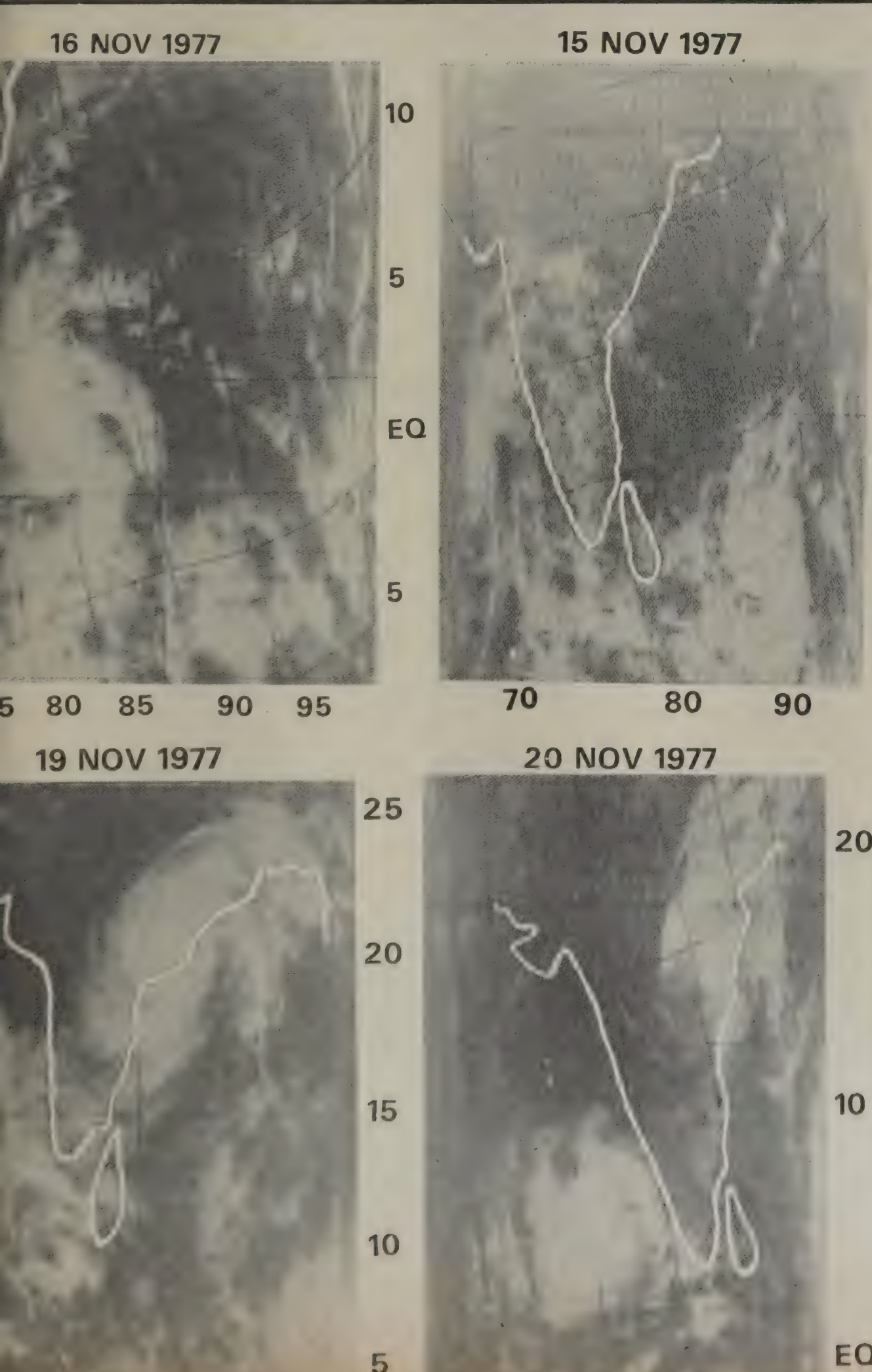


Fig. 3 (Left) Track of Nagapattinam and Chirala cyclones in November 1977. The westward moving cyclone of the Arabian Sea started moving south from 16 November and then turned eastward. The storm in the Bay of Bengal which was heading westwards towards Sri Lanka started travelling northwest from the same day and hit Andhra Pradesh on 19 November. This peculiar behaviour is due to the mutual interaction between the two cyclones, observed for the first time in the Indian area. (Numbers along the cyclone track refer to dates in November 1977)

Fig. 4 (Below) Weather satellite photographs received at Bombay between 14 November and 21 November 1977. The photograph of 17 November gives the combined view of the Masulipatnam cyclone over the Bay of Bengal and the Karwar cyclone over the Arabian Sea. The Nagapattinam cyclone, instead of weakening overland after crossing the coast, dipped over the Arabian Sea and reintensified



The Gopnath cyclone — a significant Indian study

The hazards associated with a hurricane are extremely strong wind and violent seas. Over the seas, it is very difficult to get detailed information of surface winds and waves in the hurricane field; such observations can be made only from surface vessels positioned in the area during the passage of the storm and, understandably, all surface vessels are likely to *move out* of the area once a cyclone warning has been given. The only set of documented data prior to the Gopnath cyclone of 31 May-3 June 1976 (see Fig. 6) over the Arabian Sea was by Arakawa and Suda describing the experience of the main squadron of the Imperial Japanese Fleet as it inadvertently passed through the typhoon of September 1935.

The wind and wave conditions of the Gopnath cyclone were studied by Dr. A. K. Mukherjee and T. R. Sivaramakrishnan of the Regional Meteorological Centre, Bombay, on the basis of data collected from three off-shore drilling rigs in the Bombay High area (the report was published in *Nature*, **267,** p. 236–237, 19 May 1977). The jacked-up rigs made continuous wind and wave measurements during the passage of the cyclone; Fig. 5a shows the wind-field over storm area, while Fig. 5b shows the composite chart for wave heights and directions.

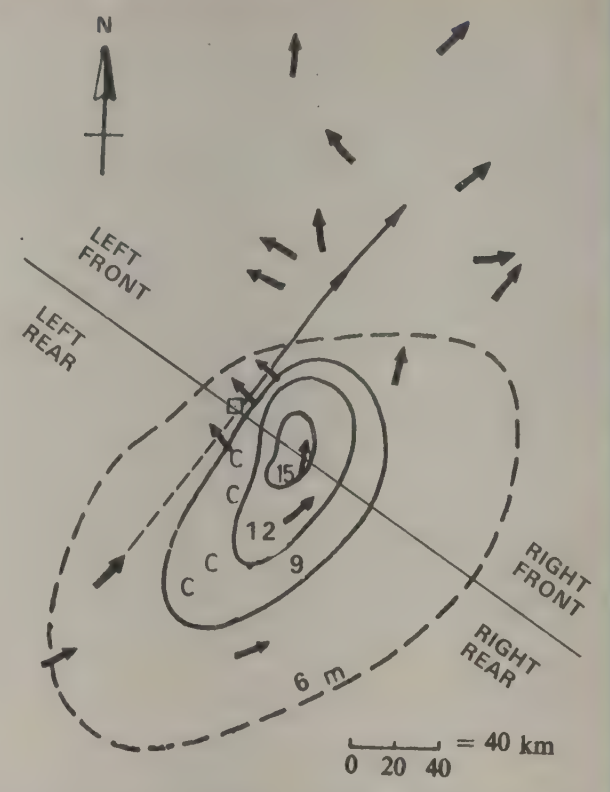


Fig. 5b Composite chart showing wave heights and directions. 'C' indicates confused direction. Wavy arrows indicate direction of waves

Two significant observations emerged: (*i*) the strongest winds were found in the right rear quadrant (unlike Arakawa's finding of the core of strong winds both in the front and the rear quadrants on the right side); and (*ii*) the highest waves were both in the front and the rear quadrants in the right (Arakawa found them in the right-rear quadrant only). The sea was confused from the centre to the right rear quadrant.

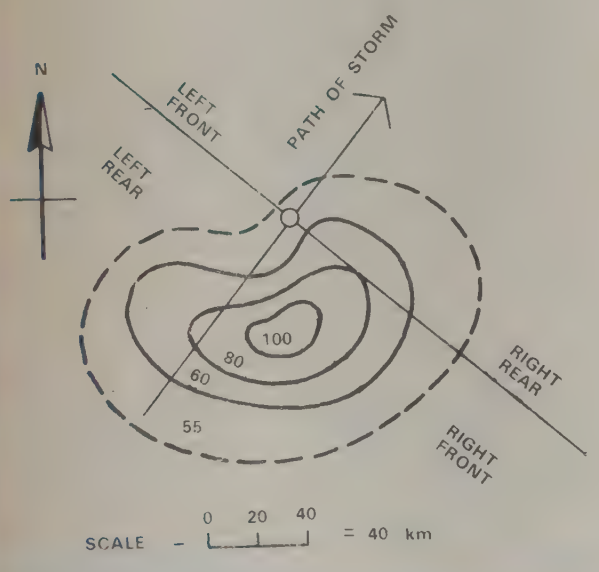
The wave periods varied between 6 and 12 seconds. The maximum energies of waves encountered by the rigs were:

Rig	*Wave energy, E* (10^6 J)
Sagar Samrat	1·72
Haakon Magnus	5·01
Shenan Doah	1·18

(Energy values are given per metre of wave crest per wavelength.)

The study, now being worked out in greater detail, will go a long way towards establishing guidelines for maritime traffic in cyclone-prone areas.

Fig. 5a Wind field over storm field (wind speed in knots) plotted during the Gopnath cyclone study by the author and T. R. Sivaramakrishnan. Lines (isotachs) are obtained by joining points of equal wind speed. Note that the core of maximum windspeed is in the right rear quadrant



but the codes prepared by the Cyclone Distress Mitigation Committees of West Bengal, Orissa and Andhra Pradesh have outlined several measures. The simplest, of course, is to evacuate people to some distance away from the coastline. During the Gopnath cyclone of 1976, timely warning enabled the Gujarat Government to evacuate people from the coast so that there was not a single death due to the storm surge.

Location and intensity

Meteorologists are very eager to know whether a tropical storm is forming. The mechanics is known, as the earlier discussion has shown. After the formation of the system, the next most important point is to know its exact location and intensity. For this, several tools are available.

Cyclones form over the sea. If on the basis of some observation made from a ship, a meteorologist locates a tropical storm and issues a forecast, all ships will move away to safer places. Thus, very few useful ship-based observations can be obtained after that. Conventional meteorological observations, therefore, are not always useful. To overcome t difficulties, advanced countries using ocean weather buoys.

However, the most useful obser tion is made by weather satellites. present, over India, weather satell pass twice a day. They can 'see vast area and can give us act pictures of cloud formations. India we have satellite pict receiving stations at Bomb Pune, Madras, Calcutta, Gauh Visakhapatnam and Delhi. Fr our experience, we already kn something about the organisation clouds in a tropical cyclone. Th from the satellite photographs, can detect the existence and, to so extent, the intensity of a tropi cyclone over the sea. Though present in India we get satel pictures only twice a day, in ma other areas of the world it is possi to have a constant watch with help of geostationary satellites wh give pictures every 24 minutes. Simi facilities will become available to Indian meteorologist after the Indi geostationary satellite is launched 1981. The satellite observation helps to continuously watch a cyclone, it has certain serious limitations. T estimated centre of a cyclone is oft found to be 100 to 200 km away fr the actual centre observed on ground. Weather satellites only g an integrated picture of clouds observed from above. It is oft difficult to estimate the strength the system over the earth's surfa from these pictures.

When a cyclone approaches t coast, coastal radars can 'see' t storm. Actually, the radars c observe only the clouds. From th one has to draw conclusions about t centre and also the intensity of t system. Cyclone warning radars c effectively see up to a distance 400 km around the station. Su radars have been installed at Calcutt Paradeep, Visakhapatnam, Madr and Bombay. One cyclone warni radar is being installed at Goa. Tw more are to be installed at Masu patnam and Karaikal. The Gopna cyclone of 1976 was tracked by th Bombay radar and it was possib to issue accurate forecast about th storm. The track of the storm seen by the radar at Bombay is show in Fig. 6. It may be noted that th track is not smooth but somewha zig-zag. It is only by his experienc that a forecaster can successfull smooth out the track so observed i radar and issue a suitable forecast.

While the radar has enriched ou knowledge about the nature of tropica cyclones, it too has some limitation While observing through the rada

nas been found that the centre of a clone does not move along a smooth th; the movement is almost always -zag. This, however, is no fault the method of observation. It is nerent in the nature of the system. In the Indian area, another limitan has been observed. Organisation d intensity of clouds show a diurnal riation. Thus, a cloud structure as served through the radar may dicate weakening of a system in afternoon, whereas surface feaes like winds, waves and surges ay remain unchanged.

Perhaps the best method of observg a cyclone is by penetrating it by craft. Such observations are being ken up in many countries. In India, , we may start doing it in the near ure. As this will help us to get details the storm structure, at least the tensity of the system can be curately determined.

Forecasting of clones consists of predicting the ange of position and intensity of e systems. A forecaster has to see e necessary conditions of formation d if they are fulfilled, he can prect the intensification of the cyclone. sually, when cyclones form over e Indian seas, they intensify and ve towards the land. However, nen cyclones over the Arabian sea ve westward, they may come over lder waters off Somalia, in which se they weaken. Normally, Indian eteorologists take four factors into nsideration: climatology, persistce, analog and steering. First, they nsider the location of the storm and m past records they know how rms over that location behave. ne average motion of all past clones is taken as a first approximaon for the movement. This method based on climatology. Second, ey consider how the movement has ken place in the recent past. It is sumed that such movement will ntinue. This is known as considerain of persistence. Third, they see hether any storm in the past, on out that calendar date, behaved milarly. It is assumed that the storm question should in that case have in an analogous manner. The urth consideration is, steering. yclones interfere with general air w up to a certain height. The 12 n level is supposed to be where such terference vanishes. Thus, it is sumed that cyclones will be steered wind at this level.

Besides these, two further considerans are taken into account. One the interaction by an extratropical eather system. Such systems have een found to have a profound influence on the movement and intensification of tropical storms. The other method is to analyse the sea surface temperature field. Energy is ultimately obtained from the sea surface. A computation of exchange of energy can give us the gradient of energy exchange. The storm tends to move towards the maximum gradient.

Even after so many different considerations, it is often found that the recurvature of a storm is difficult to forecast. Often recurvature can be anticipated in a qualitative way. The amount of recurvature and subsequent motion is very difficult to guess.

The storms of November 1977

The devastations caused by the recent cyclonic storms in November 1977 have created great interest amongst the general public. Here we give a brief history of the storms.

On 9 November, a cyclone was found to be forming over the Andaman sea. Its subsequent movement and intensification is shown in Fig. 3. On the 12th, it hit the east coast near Nagapattinam causing great devastation. It then moved over to the Arabian sea south of Kozhikode probably passing through the Palghat gap. Moving west-northwest, it came to latitude 13·5°N and longitude 66·0°E and stopped.

On 13 November another cyclone was found developing north of Sumatra. Its subsequent movement and intensification is also shown in Fig. 3. Some selected photographs of satellite observations are shown in Fig. 4.

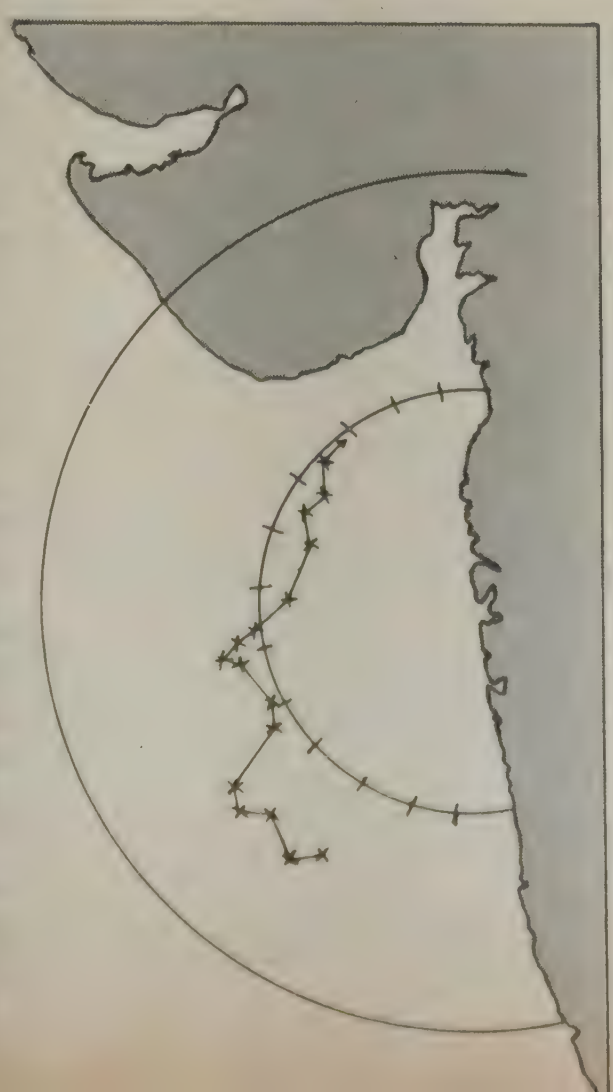
On 16 November a peculiar thing happened. The storm over the Bay of Bengal moved northwest and the one over Arabian sea moved southeast. This was against all prevailing concepts of movement of tropical storms over the Indian seas. In fact, these two storms started interacting with each other. Both the systems then rotated in an anticlockwise direction around a common centre. Such interactions are very rare and this was the first time it was noticeable in the Indian area. They continued to influence each other's movement till the Bay system hit the coast and weakened. The Arabian sea storm later hit the west coast near Karwar on the morning of 22 November.

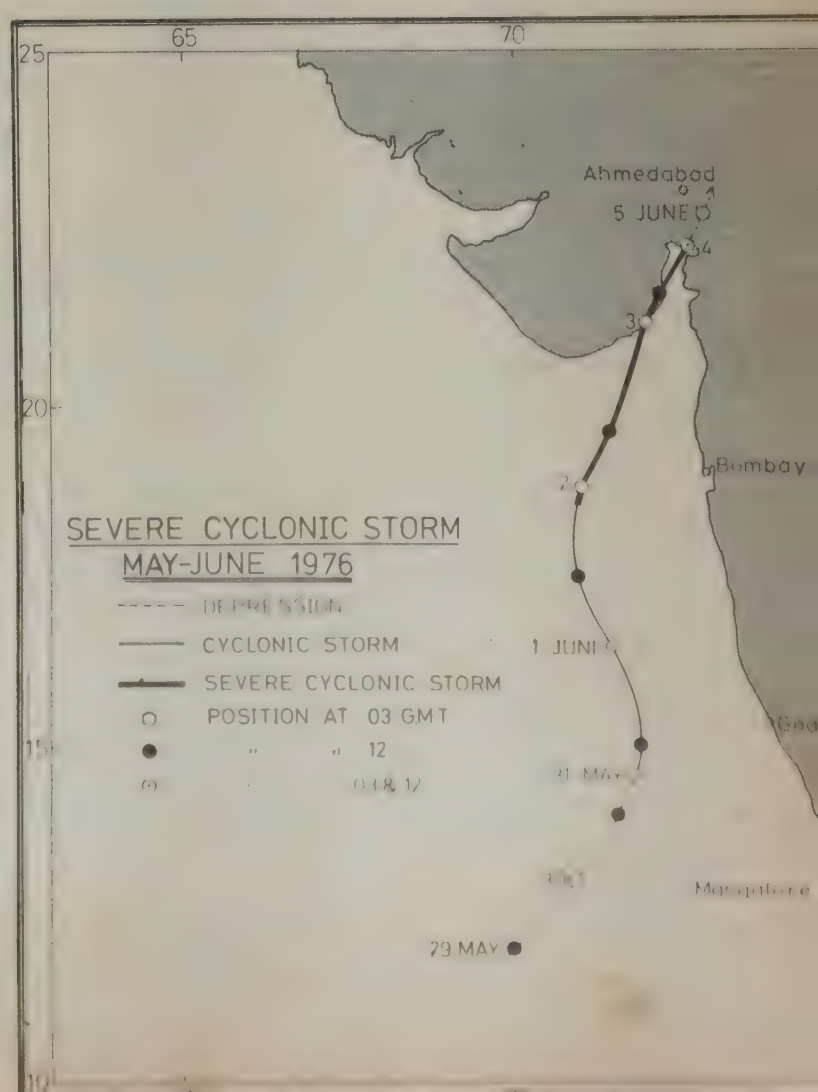
The anticlockwise rotation of two storms had given us an indication that the Bay storm might hit somewhere near Madras. But in the present case, a new complication arose. The common centre moved eastward between the morning of 17th and the morning of 18th November. This indicated that the Bay storm would move further north and hit somewhere around Masulipatnam. Accordingly, warnings were issued by the Meteorological Department.

Fighting the hurricane

There is a general feeling that since hurricanes are so destructive, we should be able to find

Fig. 6 (Left) Gopnath cyclone of May-June 1976 tracked by radar fixes from Bombay. (Right) Path of the cyclone has been plotted after smoothening out the zig-zag radar track





some method of fighting them. After World War II, when the potentialities of the atomic bombs and later the hydrogen bombs came to be realised, people started thinking of exploding such bombs in order to disturb the pattern of energy distribution associated with storms. But no experiment in this direction has yet been made since the question of radiation and fall-out associated with these bombs has not yet been solved. In fact, they might prove to be more dangerous than the cyclones themselves.

With the success of weather modification experiments (SCIENCE TODAY, July 1976), particularly the experiments on growth of cumulus clouds as well as on hail suppression, scientists began thinking of using these methods to disturb the cyclones and thus minimise the fury of the storms. In the mid-1960s, the project 'Storm Fury' started this work under the guidance of Dr. Joanne S. Simpson. The unit was based at Miami at the same place where the National Hurricane Center (for forecasting cyclones) and the National Hurricane Research Center (for researches on cyclones) are housed. The NHRC conducted experiments for several years with the help of aircraft and could derive some details of the structure of hurricanes over the Atlantic. For instance, it was realised that hurricanes have some sensitive spots and if somehow we can disturb these spots, we may be able to disturb the hurricane. In project 'Storm Fury,' several aircraft probed the structure of the hurricane by penetrating it at the same time at different heights from different directions. After gathering details about the structure and the state of maturity of the hurricanes the sensitive spots were located. The hurricane was then seeded with silver iodide, so that the growth of cloud in different sectors of the sensitive spots was disturbed. This, in turn, caused a disturbance in the temperature structure and energy inflow into the storm. Theoretically, by this method, it may be possible to reduce the fury of storms to some extent and also to divert the storm away from the expected 'hit' areas. Dr. Sessil R. Gentry, who was then Director of the NHRC, delivered a talk on this experiment before the members of the Indian Meteorological Society in Bombay in 1974. According to him, and also according to the latest reports of Project 'Storm Fury', there are some hopeful results on the reduction of the intensity of the storm and hence the US Weather Bureau is still continuing the experiment. It cannot yet be said that the track of a storm can be changed since the tracks follo by the storms depend on sev factors, many of which are of m greater scale to be affected by s experiments.

Dr. Asoke Ku Mukherjee (50), D tor, Regional Met logical Centre, Bom took his PhD in che try from Calcutta versity in 1952 after joining the In Meteorological Se in 1953, worked various places as level forecaster till I From 1970 till 1973 he worked as a expert in Sierra Leone, West Africa, b joining the RMC, Bombay. His rese interests include air pollution, atmosp chemistry, film viscosity and sea swell. was a member of the Calcutta team pioneered artificial rain-making experim in India.

In 1977, Dr. Mukherjee led India in Third Phase of the Monsoon Experi aboard the research vessel *Academician Si* in the Bay of Bengal and worked on atm pheric ozone jointly with German scient

Recommends reading: **1.** *Proceedings of Tropical Cyclone Symposium* (Brisbane 19 Issued by Director of Meteorology, M bourne. **2.** Riehl, H. & Palmen, L. B Budget of angular momentum and energ tropical cyclone. *J. Met. 14*, 150–159 Dunn, G. E. & Muller, B. Z. 1960. *Atl Hurricanes*. Louisiana State University P **4.** Mukherjee, A. K. & Sivaramakrish T. R. 1977. Surface wind and sea waves hurricane field. *Nature, 267*, 236–237.

All about the Moon

HE MOON — A NEW APPRAISAL, he Royal Society of London, 977, 606 pp, £38·00

HE MOON BOOK by Bevan M. ench, Penguin Books Ltd, 1977, 38 pp, £1·95

[N the classical British way, the first book is described as the outcome of a discussion on Moon ld by the Royal Society! This cellent volume contains a detailed chnical summary of all that has en learnt of the Moon both from the udy of lunar rocks brought back to e Earth and analysis of the surface notographically and from instruments ft on the lunar surfaces. One finds tailed research papers on various pects of the lunar surface from thorities — some of them giants in nar science. There are names such Wasserburg, Anders, Lal, Geiss, own, Runcorn, Dollfus, Gold, loore, Sonett, Kopal, O'Keefe, Ring-ood and, of course, the father of odern lunar science, H. C. Urey.

There is a total of 66 papers, vided into seven major sections, aling with the origin and evolution the Moon, the early evolution of the ust, the development of Mare basins, e history of meteoritic bombard-ent of the Moon, the present-day loon and its interaction with its vironment and internal processes.

Even though the Moon and the nar samples have been studied by numerable techniques, most interest-g information on the Moon has me from the study of its chemical mposition, radioactive age deter-ination, the study of tracks produced y cosmic ray particles as well as the udy of micro-craters on lunar rocks nd the huge impact craters on the nar surface.

Of the many findings reported, the llowing stand in the forefront. The loon, which started as a solid body bout 4·5 billion years ago (cogenetic ith the Earth), had an intense surface ctivity due to both volcanoes and rater-forming impacts of asteroids. luge basins were also formed during is period and their ages have been etermined with a high degree of recision both by photogeological ethods and radiometric dating of ocks. It is estimated that the Imbrium vent took place about 3·95 billion ears BP (before present) and the Orientale basins were formed about ·85 billion years BP, whereas the ectaris and Serenitatis regions were formed earlier, about 4·25 and 4·28 billion years ago, respectively.

It has also been found that the Moon possessed a magnetic field around 4,000 to 3,200 billion years ago, which slowly vanished except for the memory of the rocks formed during the time. By studying the remanent magnetisation in rocks formed during different times, it has been proved that the rocks must have formed in the presence of a high magnetic field. But it is still not certain whether the field was internal or due to other external causes.

The paper by Wasserburg and others gives a lucid outline of lunar chronology. The Moon underwent major differentiation to produce a rigid lunar crust within 100 to 200 million years after its formation. Up to about 4 billion years ago, the lunar surface was heavily bombarded with asteroidal bodies with a massive bombardment occurring about 3·95 billion years ago, after which the bombardment rate suddenly dropped quite low, thereby preserving the features of younger lava flows. The Moon has been more or less quiet for 3 billion years.

From studies of the chemical composition of the Earth, the Moon and the Eucrite meteorites, E. Anders discusses the possibility of all of them being derivatives of a common source after chemical differentiation. This idea is also supported by the work of Allegre and others.

Lal has discussed in detail particle irradiation of solids in space, based on the tracks observed in lunar materials. It is indeed surprising how much one could learn about the history of the Solar System from such minute tracks produced by cosmic rays and solar particles. By studying the heavy nuclei cosmic ray tracks produced in lunar minerals, a lot of information has been obtained about the evolution of the lunar regolith. For instance, the deposition rate (of grains) on the lunar surface has been obtained by this method, and is of the order of 2 to 5 mm/million years. The possibility of long-term variations in cosmic ray composition has also been revealed in similar studies.

The studies of moonquakes by D. R. Lammlein have given information about the detailed structure of the lunar interior — such as the conclusion that the top 50 to 60 km of the crust is made of *plagioclaise*-rich material and the 250-km thick upper mantle is of *olivine-pyroxene* composition. It has also been found that moonquakes are triggered by tides. A convective mechanism in the interior is proposed to explain the distribution of moonquakes, the earthside topographic bulge, the distribution of filled Mare basins and also the ancient lunar magnetic field.

There are a number of papers dealing with other physical and chemical properties of the Moon — such as viscosity, electrical properties, thermoluminescence, albedo, carbon chemistry and rare gases in lunar samples, all of which help in understanding the "still mysterious Moon".

The book is a useful compendium for researchers dealing not only with the Moon but also with the origin and evolution of the Solar System in which the Moon is a singular object and an understanding of its origin and evolution will lead to analogous ideas concerning other planets and satellites.

While the first book is comprehensible only to the experts, the second, *The Moon Book*, complements the first, and gives information to a wider audience. This exceptionally readable book provides all the excitement of lunar science — and myths too.

The initial thrill and sensationalism associated with the manned lunar missions and the awe and wonder regarding lunar rocks and soil have become part of history and is now rarely remembered. Still, people like the author and the reviewer, who had the good fortune to work with the lunar samples from the Apollo mission, cannot forget the thrill of holding the lunar samples in the hand for the first time. The author's first reaction to receiving the lunar samples was, "It isn't possible". But with the passage of time, lunar rocks and soil samples have become commonplace, so to say.

The Moon Book is a popular narration of the ideas about the Moon gathered from lunar explorations using spacecraft and particularly those from the analysis of lunar samples. The book describes the nature of the lunar surface and the lunar rocks and theories regarding the origin and evolution of the Moon. The author gives a detailed description of the lunar rocks and soil returned from Apollo missions and the inferences made regarding the structure and the origin of the Moon. A detailed analysis is made of the lunar interior, based on observations made on the

surface and from experiments conducted with lunar rocks.

Even though the number of lunar quakes is comparatively low (there are about 10 quakes per day on the Moon, nearly all of them below magnitude 2, whereas there are more than 2,500 quakes of this magnitude on the Earth), seismic records over many years from seismometers left on the Moon by astronauts have given information about the structure of the lunar interior. In fact, the seismometers on the Moon are still in operating condition, but the experiments were stopped due to lack of funds.

There is the usual description of the enigma of the origin of the Moon — but told in a more interesting way. Whether the Moon was formed out of the Earth, or both were formed together from a single primordial cloud, or whether the Moon was captured by the Earth — the three theories being romantically named as the " daughter," " sister " and " girl friend " theories — is adequately debated. There is yet again the controversy regarding the origin of the craters on the Moon. Both the impact and volcanic theories are described, from the pre-Apollo days to the present day. It is now fairly certain that most of the lunar craters are due to the impact of asteroids and meteorites. There is also evidence for some of the craters being of volcanic origin.

A chapter deals with ancient myths and earlier ideas regarding the Moon. There is the question regarding the lunar cycle and its relationship to the menstrual cycle in women. Some of the myths include the attribution of its waxing phase with life and growth and the waning phase with death and decay. According to the author, in some countries, mothers expose their babies to the light of a waxing moon to give them strength; trees are cut down under a waning moon when their vigour is supposedly reduced and the cutting is easier. Equally interesting are the popular beliefs about the origin of the Moon. In New Guinea, for instance, the Moon is believed to be a shining ball stolen from a child by the Sun-god who needed it to light up the night while he slept. And in Greenland, Eskimos warn young girls that the Moon would make them pregnant if they are unwise enough to sleep in its light!

The book also mentions some of the social aspects of the lunar explorations. " Hundreds of anonymous young men and women have spent their most productive years in frustration, mapping landing sites that were never visited, building equipment that were never used and training for missions that never flew. Thousands m would work in isolation and n frenzy . . . doing the millions of s tasks that had to be on time and to be done right, yet continu aware of how little margin universe allows for ignorance error."

Regarding the economics of lu missions, the book mentions that cost of the Apollo programme been estimated at between 25 and billion dollars for the decade 1960 This comes to about $20 per per (in the USA) annually. During same decade, the average Ameri spent each year over $80 on cigaret over $50 on beer and, over $50 liquor.

With all this outlay of manpo and money, the last word on Moon's origin is yet to be pronoun and, according to H. C. Urey, " explanations for the origin of Moon are improbable." Be that it may, the book brings out all excitement of lunar science and my in a way that can be understood an interested layman. Even the exp who knows everything about subject will be agreeably surpri that some of the abstruse, pros scientific ideas could be put into rea beautiful words.

V. S VENKATAVARADA

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What are solid state batteries?

N 1972, the UK Electricity Council successfully demonstrated a delivery van powered by a 50 h (kilowatt hour) experimental ium-sulphur solid state battery. single charging, the vehicle could up to 125 km with a maximum ed of 55 km per hour.

or several reasons, the develop- nt of battery-driven vehicles is ng given high priority these days. e energy crisis has heightened the ency of developing substitutes for internal combustion engine; hly reliable, safe and high-capacity teries present an effective alter- ive.

he conventional lead-acid battery ot suitable for vehicle propulsion. as a low energy density (the ratio tored energy to the weight of the tery) of 20 to 40 Wh/kg (watt r per kilogram) which limits the ge of the vehicle to a mere 40 to km. It has been estimated that to pete with gasoline-driven vehicles, s essential to develop a battery em with a capacity of 150 kWh l an energy density of 200 Wh/kg. h a battery should be capable of ning a vehicle up to 450 to 500 km hout recharging. No battery em, currently in use, meets these cifications, but soon solid state teries may provide the answer. e "Will Cars Go Off the Roads?", ENCE TODAY, February 1974, 43.)

Besides the low-energy density, the ueous battery systems (for example, lead-acid battery) suffer from eral other limitations. The main is the limited life of the cell which ults from corrosion reactions of the ctrode materials in the highly ducting, acid electrolytes. Cell kage and creeping of electrolyte cessitate special sealing techniques ich add to the cost. With recent hnological advancements such as art pace-makers and electronic tches, extremely small size tteries, with a guaranteed life of a years, have become very desirable. ueous batteries cannot be minia- ised to the required extent. Also, nventional batteries can satis- torily function only over a narrow mperature range.

Solid state batteries hold the omise of alleviating these problems. cording to a US report, 20,000 ium-iodine solid state cells have en manufactured and implanted heart pace-makers without a single lure; the normal functioning of this pe of battery is assured for ten years. And for the same performance, a solid state battery may be ten times smaller than the conventional lead-acid battery.

What is a solid state battery? Like any other battery, it consists of a positive electrode (anode), a negative electrode (cathode) and a suitable electrolyte between the two electrodes. The electrode materials may either be in the molten state (for high-power batteries) or they may be solids (for low-power batteries), but the electrolyte is definitely a solid material.

To illustrate the working of the battery, let us consider a simple system, the silver-silver iodide-iodine cell. The cell has a silver anode, an iodine cathode and silver iodide as electrolyte (Fig. 1).

Whenever a load, for example, a flash light, is connected between the anode and the cathode, silver ions (Ag^+) diffuse through the solid electrolyte and combine with the iodine (I_2) at the cathode to form silver iodide (AgI). Each diffusing silver ion liberates one electron at the anode which moves towards the cathode through the external circuit and accounts for the flow of electric current through the device. The electrode reaction at the anode is:

$Ag \rightarrow Ag^+ + e^-$
(neutral silver atom) (silver ion) (free electron),

and at the cathode:

$2Ag^+ + I_2 + 2e^- \longrightarrow 2AgI$.

The e.m.f. of a cell using the above reaction is around 0·6 volt.

When the battery is recharged, the reverse reactions occur at the electrodes. Silver iodide is dissociated into silver and iodine and silver diffuses back to the anode.

The most important constituent in a solid state battery is the solid electrolyte, through which the ions (silver ions in the above example) diffuse. The speed of this diffusion process in the electrolyte determines a critical factor — the current density of the battery, that is, the amount of current available from a unit area of the electrodes. It is important to know the current density in a battery because this parameter characterises the application. For example, in heart pace-makers, extremely small currents are involved; therefore, a battery with a current density of a few micro-amperes is adequate. On the other hand, large current densities of the order of 0·1 ampere/cm² are needed for vehicular or traction batteries.

However, the choice of solid electrolyte materials is limited because, unfortunately, not many solids have the property of permitting fast ion diffusion at room temperature. This property is known as "fast ion conduction", and materials exhibiting it are called "fast ion conductors" or "super ion conductors". In fact, batteries which utilise super ion conductors have sometimes been called "super batteries" instead of "solid state batteries". [Super ion conducting materials are very different from ordinary electric conductors like metals, in which electrical conduction takes place due to the free electrons present in the material in abundance. In super ion conductors, almost the whole conductivity results from ionic motion only. For battery

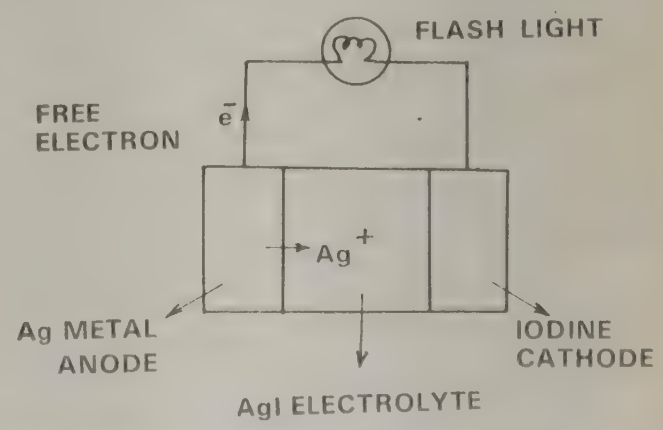


Fig. 1 (above, right) A typical solid state cell

Fig. 2 (right) The first sodium-sulphur battery powered van demonstrated in 1972 by the UK Electricity Council. (Courtesy: D. Reidel Publishing Company, Holland/USA)

application, the super ion conductors must have a high ionic conductivity ($\sim 10^{-2}$ ohm^{-1} cm^{-1} or higher) at room temperature and a negligibly small electronic conductivity (at least 100 times smaller than ionic conductivity). The presence of electronic conduction in the electrolyte amounts to self-discharge, adversely affecting the life and performance of the cell.]

The best solid electrolyte developed so far, for work at room temperature, is rubidium silver iodide ($Rb\ Ag_4I_5$). It is used in low-power batteries with silver and rubidium iodide electrodes. The voltage of a single cell is 0·6 volt.

The sodium-sulphur battery has also been quite successful. It is most popular among high-power rechargeable solid state batteries. The principle of the sodium-sulphur battery was first demonstrated in 1967 by the Ford Motor Company, USA, and the task of designing and building a sodium-sulphur traction battery was completed in 1972 by the UK Electricity Council. Nine hundred and sixty cells arranged in 40 modules of 24 cells each were used in the first experimental battery-operated van.

The sodium-sulphur battery makes use of liquid electrodes — molten sodium anode and a molten sulphur cathode — with ceramic beta alumina solid electrolyte. Sodium ions can diffuse rapidly through this electrolyte at 300° to 400°C. When the cell is discharged, diffusing sodium ions combine with sulphur to form sodium sulphide which gets dissociated on recharging; the cell thus returns to its original condition. The cell voltage is 2·0 volts. The theoretical energy density is 790 Wh/kg, but when the weight of the electrolyte and container, etc is accounted for, an energy density of only 250 to 300 Wh/kg is obtained in practice; even so, this is ten times higher than the energy density in the lead-acid battery. Thus, for the same performance, a sodium-sulphur battery will be roughly ten times smaller in size and weight compared to a lead-acid battery.

Another high-power battery is the lithium-lithium chloride system. It consists of a negative electrode of a solid lithium-aluminium alloy and a positive electrode of solid iron sulphide. The electrolyte is a molten salt of lithium chloride and potassium chloride which melts at 352°C. The cell operates at around 400°C.

The sodium-sulphur battery is more promising compared to the lithium-lithium chloride cell because the basic constituents (sodium and sulphur) are available in plenty at a low price. But the fact that the cell works at a temperature of 300° to 400°C is a big disadvantage. It requires special

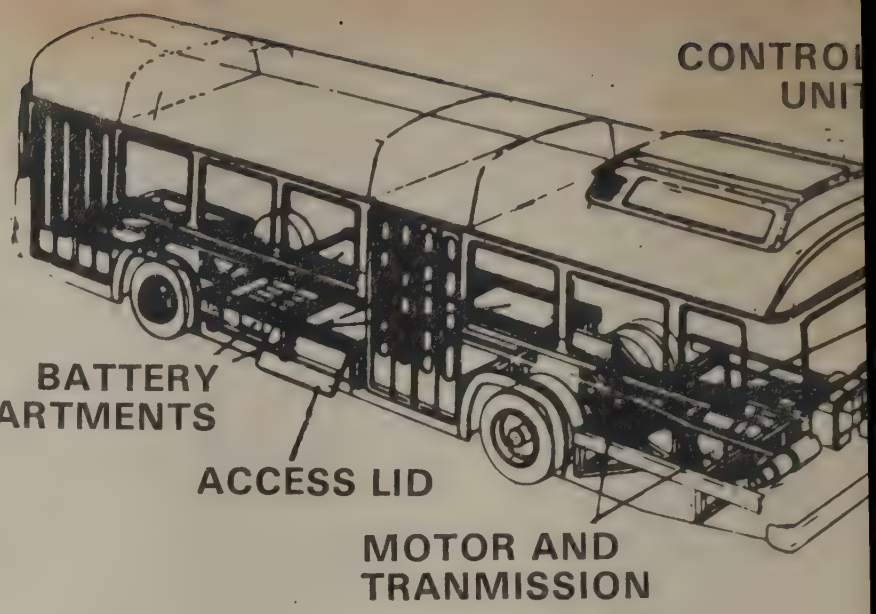


Fig. 3 A conceptual battery layout in a bus (Courtesy: D. Reidel Publishing Company, Holland/USA)

maintenance and poses safety problems.

Since these high-power batteries can store electrical energy in bulk, they can be used in load-levelling, that is, they will supply electrical power during peak consumption and get recharged at off-peak hours.

World-wide efforts are being made to improve the existing battery systems and develop new materials and new systems. There is a growing emphasis on the use of solar energy these days. Scientists have started working in direction and photo-electrochem battery systems for the utilisatio solar energy represent a signifi step. Battery research is in prog in the USA, England, Japan, Fra Italy and Germany. In India, Department of Science and Tech logy is financing some projects al these lines.

DINESH C. DU

[Mr. Dube is Lecturer in Physics at Indian Institute of Technology, Delhi.]

TELL US WHY...

. . . matter glows when heated?

Why do things become 'red-hot'? Why do they change colour when heated still further, and become 'white-hot'?

As we discussed in an earlier article (SCIENCE TODAY, September 1977, p. 34), heat radiation is but a form of electromagnetic radiation — the radiation which is emitted by oscillating electric charges. And just as sound waves can be produced in different pitches, electromagnetic waves can be produced in different 'colours' depending on the frequency of oscillation of the electric charge. Low frequencies correspond to the invisible radiation like radio waves and 'infra-red' radiation. As the frequency is increased, the radiation becomes visible — first as red waves, then, as the frequency is increased still further, orange, yellow, . . . blue and violet. Beyond this, the electromagnetic waves are again invisible: ultraviolet, X-rays, Gamma-rays and so forth.

No matter what material a thing is made up of, be it the Sun, or merely a piece of iron, when it is heated to a definite temperature it emits a universal combination of electromagnetic frequencies (which depends only on the temperature and not the material), together with some enhanced frequencies (spectral lines) which do depend on what kind of atoms and molecules the thing is made up of. The "universal combination" portion is known as the heat radiation of the body, or black body radiation. The name is a little misleading. Black body radiation is invisible at low temperatures, appears red at se hundred degrees centigrade, white 6,000° K and would appear bluish at higher temperatures, which is why s stars which are hotter than the Sun ap to be distinctly bluer than others which similar to the Sun.

Black body radiation results when a l number of electronic charges are oscilla randomly. Thus, when we heat a piec iron, we, in effect, pour random energy the material, which sets everything in moving in a disorderly fashion. The cr lattice formed by the atomic nuclei, electrons which wander between lattices — are all set into wild and cha oscillatory motion. The radiation they is, therefore, also disorderly, and thi what constitutes black body radiatio that temperature, which may be define the most disorderly (maximum entro combination of frequencies, at the g temperature.

Large numbers of electrons are neces for the production of black body radiat because, in single atoms, the electrons not move randomly but in well-defi orbits. Single atoms do not produce b body radiation. They can be excited but heated, because heat requires the possib of randomness, and single atoms are sufficiently random. Single atoms molecules emit the spectral lines refe to earlier. But in any macroscopic b randomness is possible.

The random excitation of macrosc bodies corresponds to the glow s bodies emit when heated. This is things get red, and white hot, and tungsten filament lamps work. But ' lighting' is also possible by the excita of single atoms or molecules. This the principle on which the other w known form of illumination, the tubel (fluorescent lamp), works.

VIVEK MONTEI

IC – LED CONTINUITY CHECKER

THIS is a fully solidstate continuity checker using an integrated circuit (IC) operational amplifier 741C and a light-emitting diode (LED). This continuity checker is mainly useful while repairing modern solidstate electronic appliances such as radios, TVs, tape-recorders, intercoms, calculators, etc. While tracing the circuit of the appliance, the continuity check is carried out with voltage and current of the order of a fraction of a millivolt and a fraction of a milliampere. As the applied voltage and current are so low, the continuity checker is safe for all modern sensitive ICs. All semiconductors, including ICs, capacitors and resistors (above 1 ohm), do not provide any continuity path and thus the continuity checker does not give the false continuity indication, unlike other continuity checkers and multimeters.

The continuity checker requires very few components and works on two 4·5 volt battery sources. The operational amplifier IC is used without any negative feedback, thus the amplification provided by it is extremely high. The two inputs of the IC, invert and non-invert, are connected across a 1 Ohm resistor which provides slightly positive voltage to the invert input terminal of the operational amplifier, higher than the non-invert input terminal by about a fraction of a millivolt. Thus, the output voltage provided by the operational amplifier with such a high gain is full negative in comparison with the zero voltage line. When the 1 Ohm resistor is shorted, the output goes full positive and the LED lights up. The diode and resistor in series with the LED are, respectively, for preventing the reverse voltage and limiting the current through the LED.

A plastic ball-pen body as a probe and a crocodile clip can be used as continuity sensing terminals. For convenience of handling, the LED can be kept on the top of the probe, by running two additional wires to the probe, as shown in the diagram. The rest of the circuit, including the battery cells, can be housed in a separate enclosure.

The IC 741C is available in three different types of casings. The pin connections of the IC 741C shown in the diagram of the continuity checker are with reference to the 8-pin metal envelope, which is the most easily available, and 8-pin plastic dual in-line package; for 14-pin plastic dual in-line package, please refer to the pin connections shown in the diagram and make necessary changes.

When the construction of the unit is complete, you may switch on the supply, after thoroughly checking the circuit. Keeping the probe-crocodile clip shorted together, adjust the offset-null potentiometer such that the LED just lights up. Now the continuity checker is ready for use.

You will need:

Semiconductors: IC 741C, 1 No.; LED — 1 No.; OA 85 or BY 125, 1 No.

Resistors: 10 K, 2 Nos.; 1 K, 2 Nos.; 100 Ohms, 1 No.

Potentiometer: 10 K carbon preset, 1 No.

Switch: 2 pole on/off

(Approximate cost of electronic components: Rs 30)

Battery: 1·5 volt cells, 6 Nos.

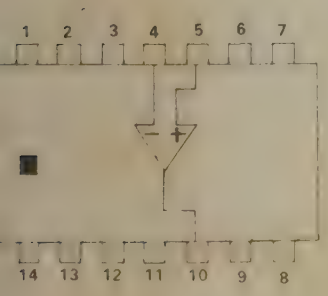
Misc.: Vero board, wires, solder, screws, suitable enclosure, ball-pen body, crocodile clip, battery holder, etc.

A.V.B.

DRY CELL RECHARGER FOR 4 CELLS

MANY readers wrote me asking how to modify the dry cell recharger (October 1977) for recharging four cells instead of two. The circuit diagram (p. 59) is of the modified recharger suitable for simultaneous recharging of four cells.

CONNECTION DIAGRAMS OF IC 741C (BOTTOM VIEW)



A-PACKAGE
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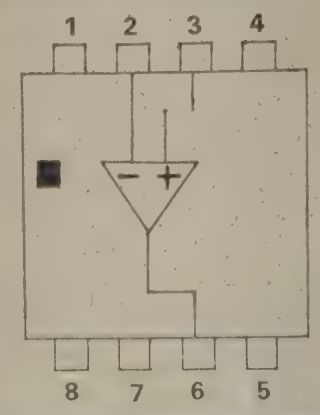
4 INVERT INPUT
5 NON-INVERT INPUT
6 —VE
9 OFFSET NULL
10 OUTPUT
11 +VE



V-PACKAGE
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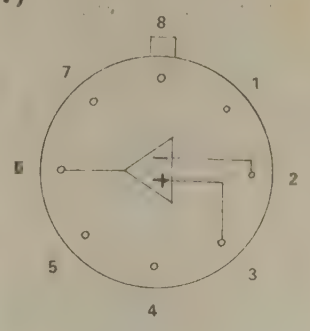
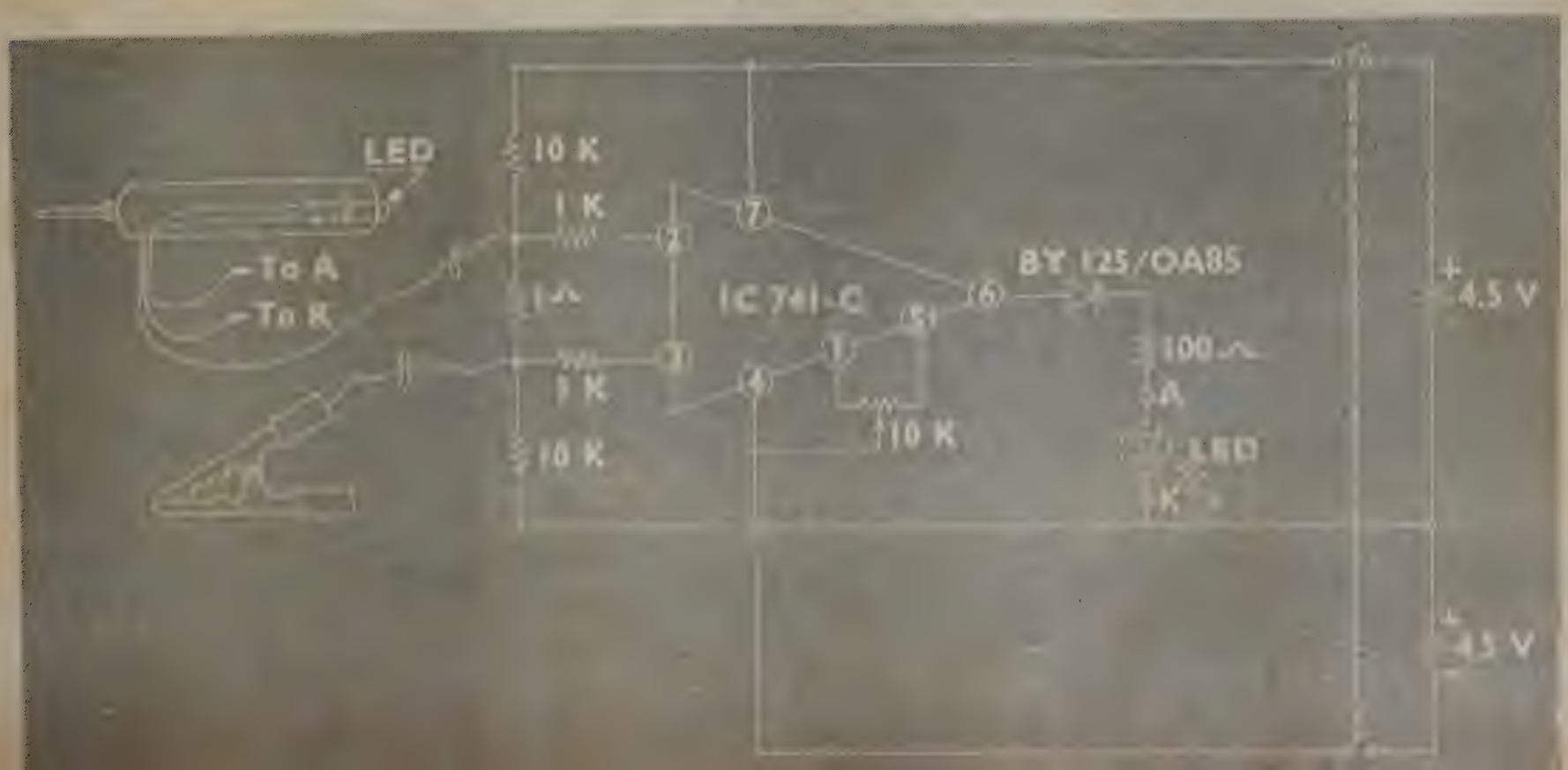
2 INVERT INPUT
3 NON-INVERT INPUT
4 —VE
5 OFFSET NULL
6 OUTPUT
7 +VE



T-PACKAGE
1 OFFSET NULL
2 INVERT INPUT
3 NON-INVERT INPUT
4 —VE
5 OFFSET NULL
6 OUTPUT
7 +VE



The first signs of gum troubl

Plaque
is the invisible film of bacteria that forms around your teeth and gums all the time. If neglected, plaque leads to tartar.

Tartar
collects at the base of your teeth, irritates your gums and causes swelling. Later on, gums and bone may recede causing teeth to fall out.

Bleeding gums
Weak and spongy gums may bleed during brushing. Although this may be painless, bleeding gums can lead to serious problems.

Dentists say

Regular Brushing of Teeth and Massaging of Gums Check Gum Troubles and Tooth Decay.

For proper dental care, brush your teeth correctly and massage your gums—night and morning with Forhan's. And insist on Forhan's Double-Action Toothbrush, specially designed to massage gums while it cleans teeth.

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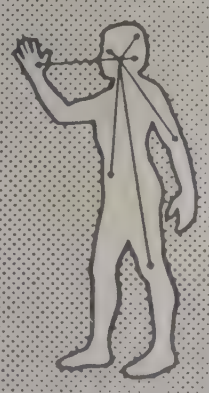

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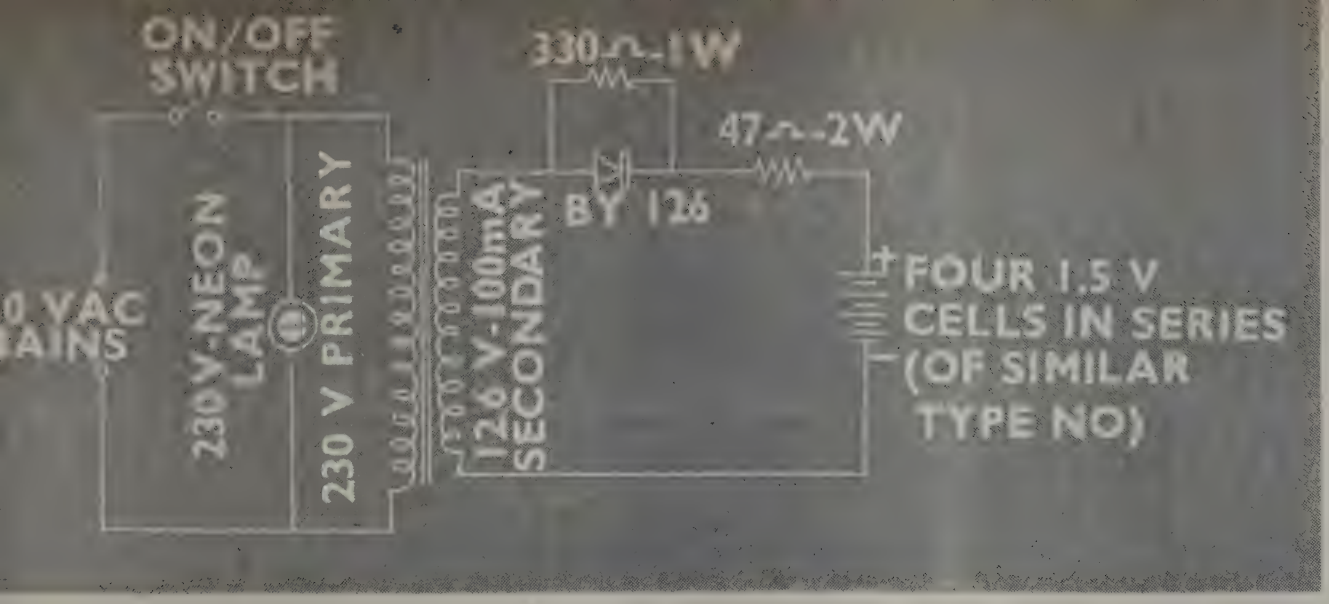


You will need:

Silicon rectifier : BY 126 or BY 125, 1 No.

Transformer : Pri.: 230 VAC;
Sec.: 12·6 V—100mA, 1 No.

Resistors : 47 Ohms — 2W, 1 No.
330 Ohms — 1W, 1 No.

Misc. : 230V neon lamp, battery holder, on/off switch, wires, solder, screws, suitable enclosure, etc.

Approximate cost: Rs. 25.

ANIL V. BORKAR

As all four cells are charged in eries, the amount of charging current passing through all the four cells is the ame. Thus, to get uniform charging of ll the four cells, they must be of the ame age and have been equally used efore recharging.

The detailed explanation of the echarging process and the precauions have been given in the October 977 issue.

The chart alongside gives the duration of charging for different cell types.

The recharged cells have poor shelf life. Therefore, put them back into service immediately. The quality of recharged cells depends upon their age and how much they were used when new.

Don't keep the dry cells in the recharger when the charger is not connected to the mains supply. Otherwise, cells will discharge through the two resistors and transformer winding.

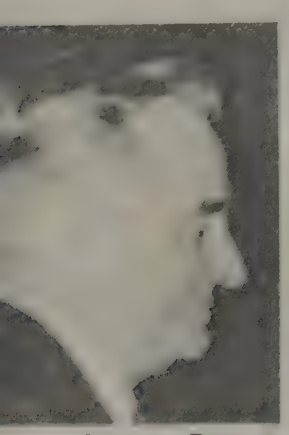
RECHARGING CURRENT

(When the discharged cell emf is 4·8V=25 mA approx. and when the charged cell emf is 6V=12 mA approx.)

Cell type No.	Recommended charging duration
1015	4–6 hours
1035	6–9 hours
1055	12–15 hours

AWARDS & APPOINTMENTS

Kalinga Prize



George Porter

A. I. Oparin

The Kalinga Prize for 1976 has been shared by two scientists — Academician A. I. Oparin of the USSR and Prof. Sir George Porter of the UK. The Kalinga Prize, awarded for work in popularising science, was instituted in 1952 by Mr. Biju Patnaik, former Chief Minister of Orissa, and now Union Minister for Mines and Steel, and is administered by the UNESCO.

A biochemist and a member of the Academy of Sciences of the USSR, Oparin (84) is the President of the International Society for the Study of the Origin of Life. His main work deals with biochemistry of plants and the origin of life on the Earth. His main writings are : *The Origin of Life on the Earth, Life: Its Nature, Origin and Development,* and *The History of the*

A Nobel-laureate in Chemistry, Prof. Sir George Porter (58) is the Director of the Royal Institution of Great Britain and the Fullerian Professor of Chemistry there. He has tried to popularise science, particularly among young people, through a series of films (*The Laws of Disorder*), science lectures and lecture-demonstrations.

Electronics Commission reconstituted

The Electronics Commission has been reconstituted. The members of the Commission, headed by Prof. M. G. K. Menon, Secretary to the Electronics Department, are : V. Shankar, Principal Secretary to the Prime Minister, N. M. Sen, former Defence Production Secretary, Lt-Gen Garewal, Chairman, Coal India Ltd, and Prof. Yash Pal, Director, Physical Research Laboratory, Ahmedabad. Mr. C. R. Subramaniam, Chairman, Bharat Electronics Ltd, and Mr. K. S. Rao, Managing Director, Electronics Corporation of India Ltd, have been dropped from the Commission.

P. B. Sarkar Endowment Prize

The prize, endowed by Dr. P. B. Sarkar, a former Director of the Jute Technological Research Laboratory, is for outstanding research calculated to lead to enhanced food production in India. Worth Rs 5,000, the award for the triennium 1974-77 has been made to Dr. K. Krishnamurthy, Professor and Head of the Department of Agronomy, University of Agricultural Sciences, Bangalore, for his outstanding contributions in agronomy. These include measures for the control of the noxious weed *Parthenium*, and the use of growth analysis technique

BRAIN TEASERS

GOD'S GAME: It is Hindu mythology again. Ganesh, the Remover of Obstacles, rode on a rat. Brahma, riding on a swan, was the Creator. Vishnu, with garuda as his vehicle, was the Protector, and Shiva, the Destroyer, rode on the bull.

One day all these gods met and decided to completely reshuffle their vocations and vehicles in all respects. They even changed their names. In the new set-up, Shiva gets garuda. The Destroyer gets the rat and Vishnu is the Remover of Obstacles. If the Protector takes the swan, then Brahma wants the bull.

Can you work out the new set-up?

V. A. SHENAI

(Solution next month)

Solution to last month's Brain Teaser

In the new set-up, Kubera in the west could not be the Lord of Death, Seas or Wealth. Hence he became the Lord of Rains. The new Lord of the Seas in the south could not be Yama, Kubera or Varuna; so he is Indra. Since Varuna is the new God of Death, Yama had to be the God of Wealth. Since Wealth cannot now go with north, it has to go with east. The entire new set-up is as follows:

N Varuna (Death)
Kubera W (Rains) ←—|—→ E Yama (Wealth)
S Indra

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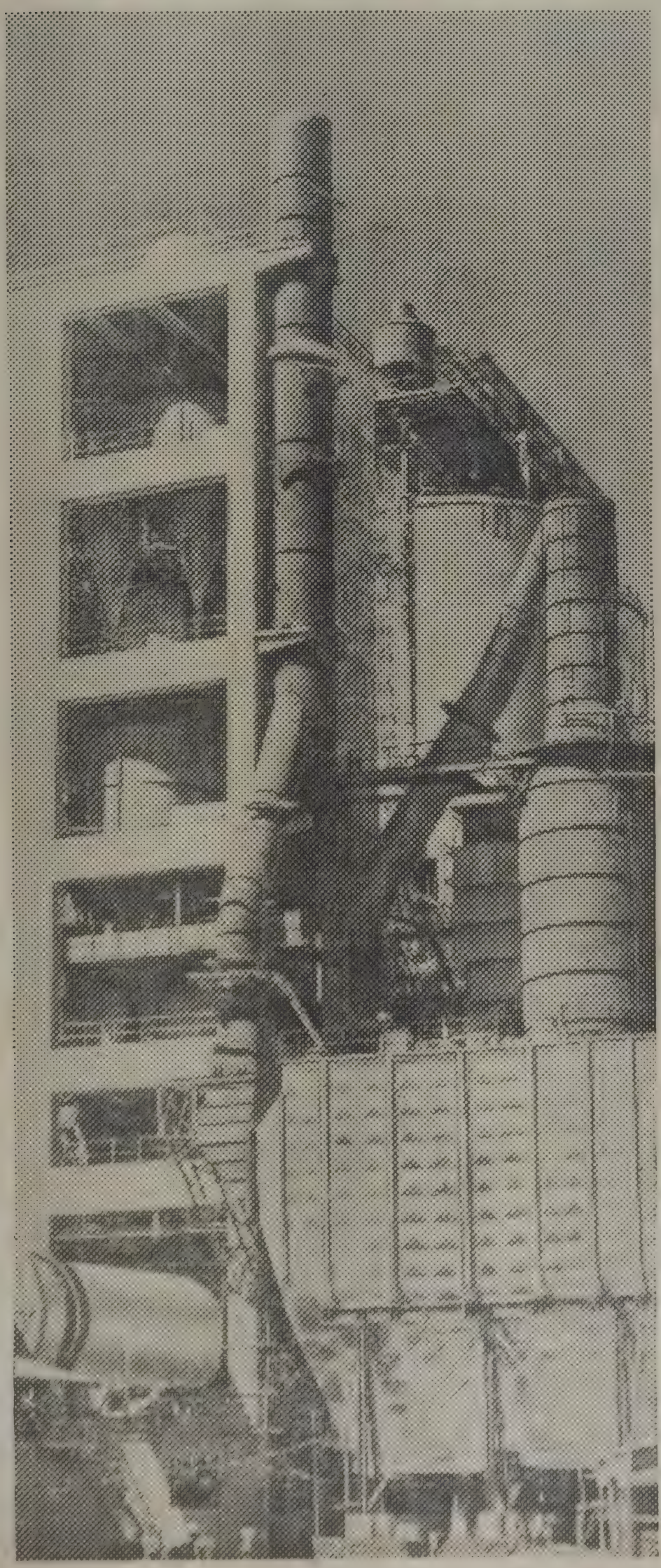

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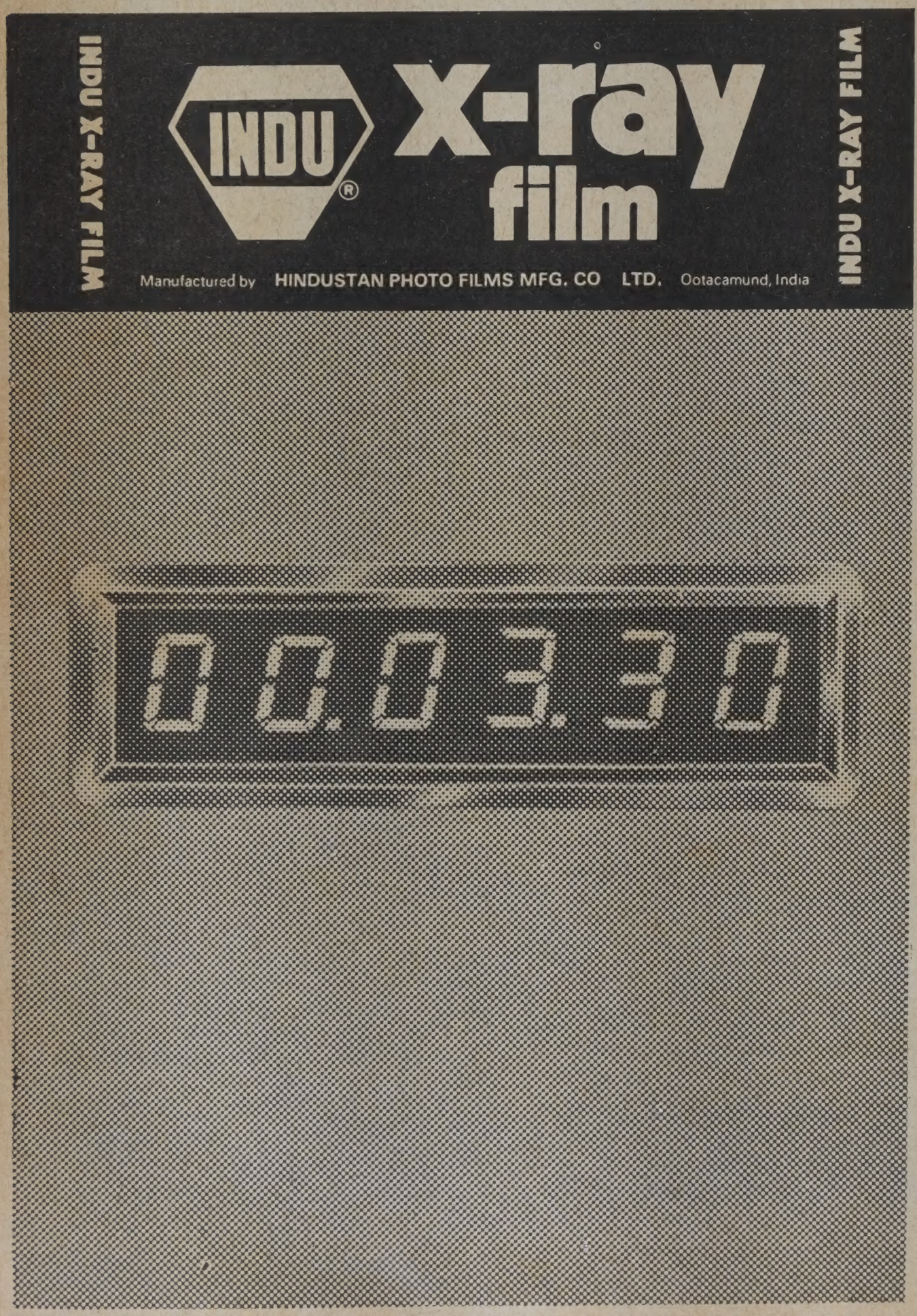

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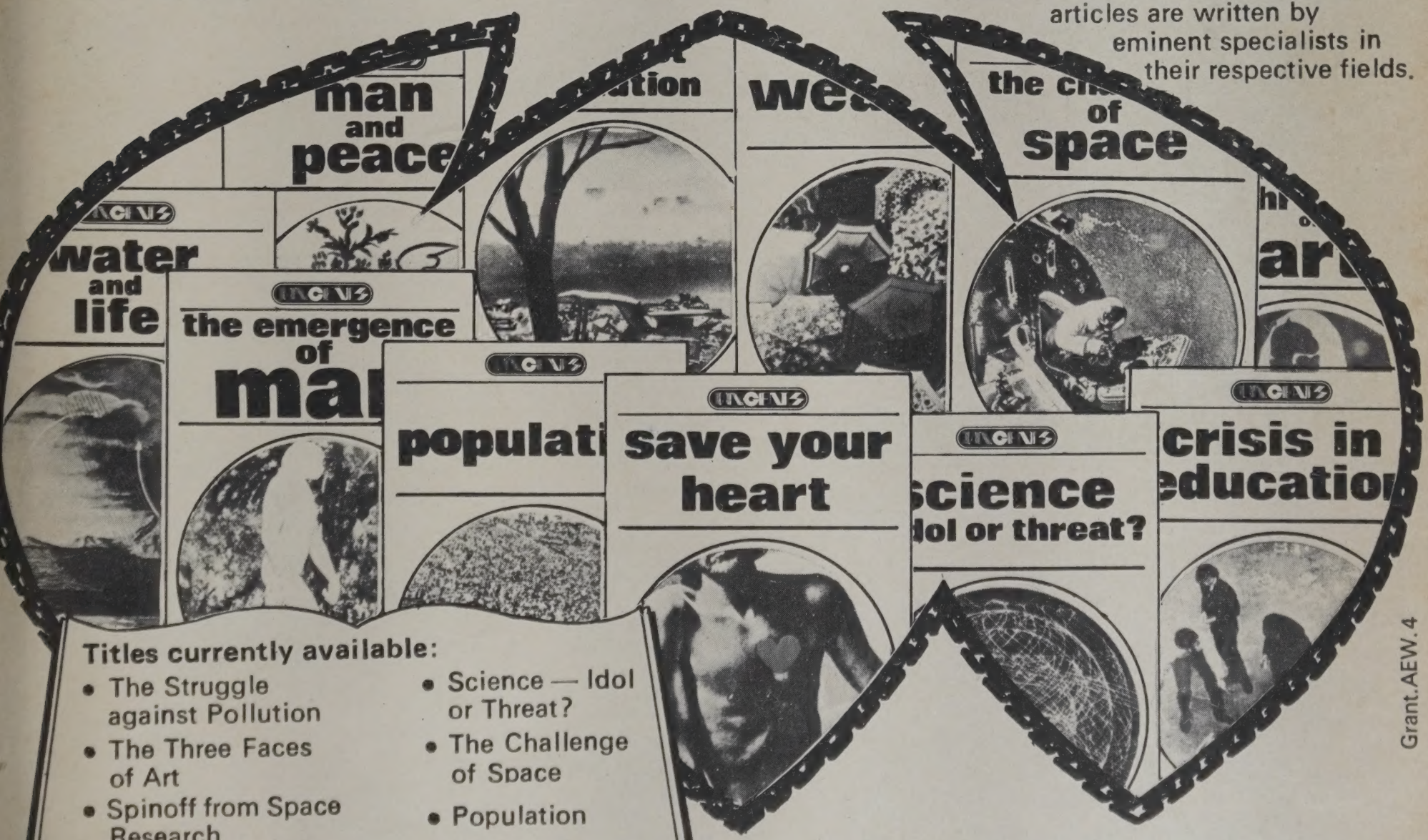

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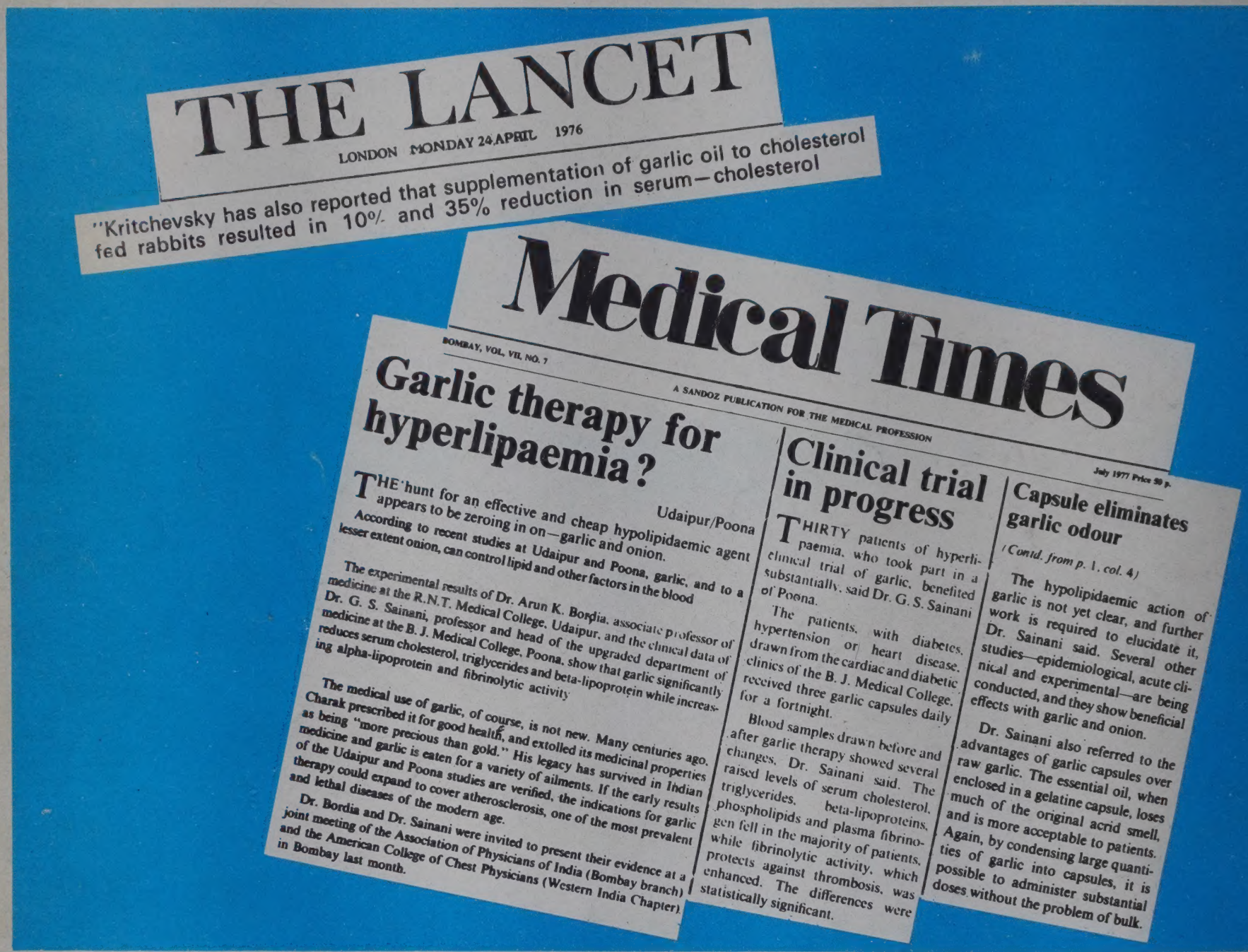

THE LANCET

LONDON MONDAY 24 APRIL 1976

"Kritchevsky has also reported that supplementation of garlic oil to cholesterol fed rabbits resulted in 10% and 35% reduction in serum—cholesterol

Medical Times

BOMBAY, VOL. VII, NO. 7

A SANDOZ PUBLICATION FOR THE MEDICAL PROFESSION

July 1977 Price 50 p.

Garlic therapy for hyperlipaemia?

Udaipur/Poona

THE hunt for an effective and cheap hypolipidaemic agent appears to be zeroing in on—garlic and onion.

According to recent studies at Udaipur and Poona, garlic, and to a lesser extent onion, can control lipid and other factors in the blood

The experimental results of Dr. Arun K. Bordia, associate professor of medicine at the R.N.T. Medical College, Udaipur, and the clinical data of Dr. G. S. Sainani, professor and head of the upgraded department of medicine at the B. J. Medical College, Poona, show that garlic significantly reduces serum cholesterol, triglycerides and beta-lipoprotein while increasing alpha-lipoprotein and fibrinolytic activity

The medical use of garlic, of course, is not new. Many centuries ago, Charak prescribed it for good health, and extolled its medicinal properties as being "more precious than gold." His legacy has survived in Indian medicine and garlic is eaten for a variety of ailments. If the early results of the Udaipur and Poona studies are verified, the indications for garlic therapy could expand to cover atherosclerosis, one of the most prevalent and lethal diseases of the modern age.

Dr. Bordia and Dr. Sainani were invited to present their evidence at a joint meeting of the Association of Physicians of India (Bombay branch) and the American College of Chest Physicians (Western India Chapter) in Bombay last month.

Clinical trial in progress

THIRTY patients of hyperlipaemia, who took part in a clinical trial of garlic, benefited substantially, said Dr. G. S. Sainani of Poona.

The patients, with diabetes, hypertension or heart disease, drawn from the cardiac and diabetic clinics of the B. J. Medical College, received three garlic capsules daily for a fortnight.

Blood samples drawn before and after garlic therapy showed several changes. Dr. Sainani said. The raised levels of serum cholesterol, triglycerides, beta-lipoproteins, phospholipids and plasma fibrinogen fell in the majority of patients, while fibrinolytic activity, which protects against thrombosis, was enhanced. The differences were statistically significant.

Capsule eliminates garlic odour

(Contd. from p. 1, col. 4)

The hypolipidaemic action of garlic is not yet clear, and further work is required to elucidate it, Dr. Sainani said. Several other studies—epidemiological, acute clinical and experimental—are being conducted, and they show beneficial effects with garlic and onion.

Dr. Sainani also referred to the advantages of garlic capsules over raw garlic. The essential oil, when enclosed in a gelatine capsule, loses much of the original acrid smell, and is more acceptable to patients. Again, by condensing large quantities of garlic into capsules, it is possible to administer substantial doses without the problem of bulk.

Professional medical journals, the Lancet from London and Medical Times from Bombay widely read by doctors in India and abroad have reported favourably on the medicinal uses of garlic in effectively reducing cholesterol and for other related diseases. After conducting clinical trials which are still continuing, we at Thomas Pharmaceuticals, are able to offer you the benefits of this amazing and traditionally well known ayurvedic herbal remedy, after completely eliminating its offensive odour. The active principle of garlic which is carefully extracted from garlic pods, is now presented in a scientifically measured-dosage, odourless Lasona capsule without sacrificing garlic intrinsic qualities.

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